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Park et al.

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(54) POSITION MEASURING APPARATUS, PEN AND POSITION MEASURING METHOD

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(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 63 days.

(21) Appl. No.: **14/625,069**

(22) Filed: **Feb. 18, 2015**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation-in-part of application No. 13/857,713, filed on Apr. 5, 2013, now Pat. No. 9,495,045.

(30) **Foreign Application Priority Data**

May 11, 2012 (KR) 10-2012-0050371

(51) **Int. Cl.**

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G06F 3/041	(2006.01)
G06F 3/044	(2006.01)
G06F 3/0354	(2013.01)

(52) **U.S. Cl.**

CPC ***G06F 3/0418*** (2013.01); ***G06F 3/0383*** (2013.01); ***G06F 3/03545*** (2013.01); ***G06F 3/044*** (2013.01); ***G06F 3/0414*** (2013.01); ***G06F 3/0416*** (2013.01); *G06F 2203/04104* (2013.01); *G06F 2203/04106* (2013.01); *G06F 2203/04112* (2013.01)

(58) **Field of Classification Search**

CPC G06F 3/044; G06F 3/03545; G06F 3/0416; G06F 2203/04106; G06F 2203/04104

See application file for complete search history.

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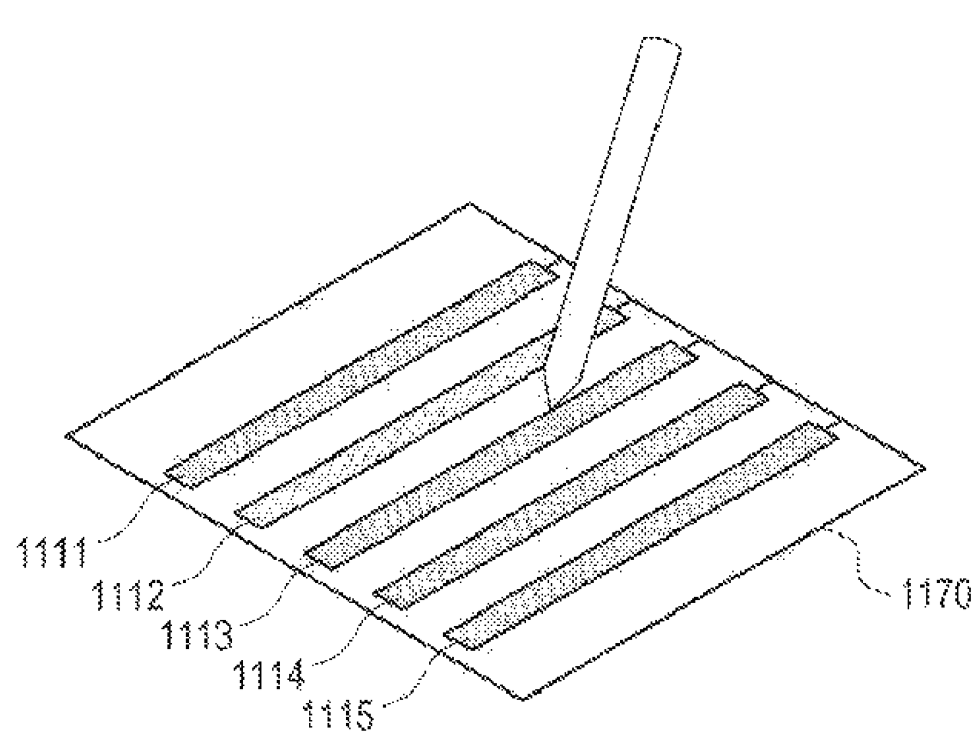
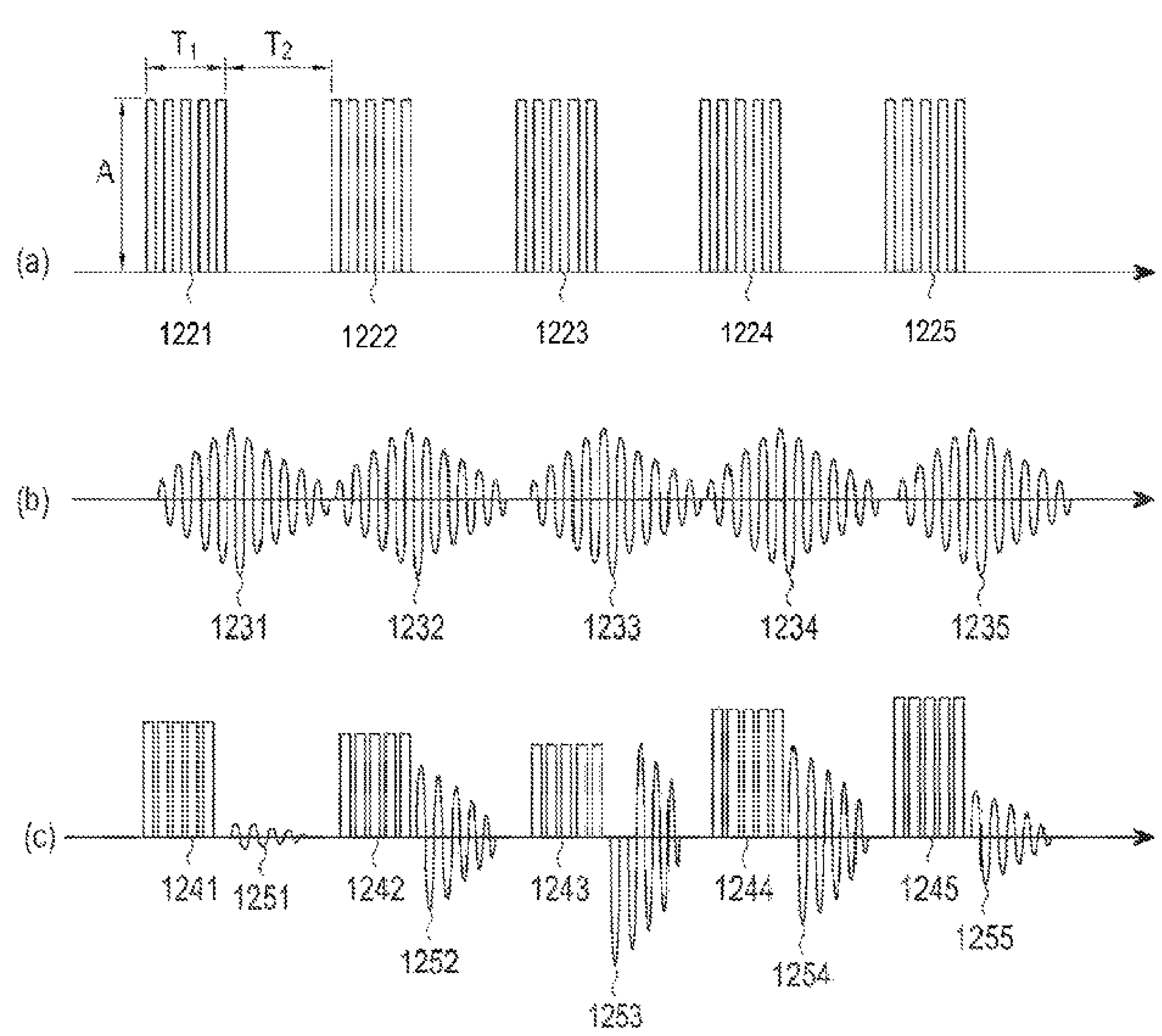
Assistant Examiner — Amy Onyekaba
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

A position measuring apparatus that measures an input position of a pen is disclosed. A position measuring apparatus according to an embodiment of the present disclosure may include one or more electrodes, and a control unit that controls to transmit an electric field transmission signal generated from one or more electrodes to the pen and receives an electric field reception signal corresponding to the electric field transmission signal.

12 Claims, 42 Drawing Sheets





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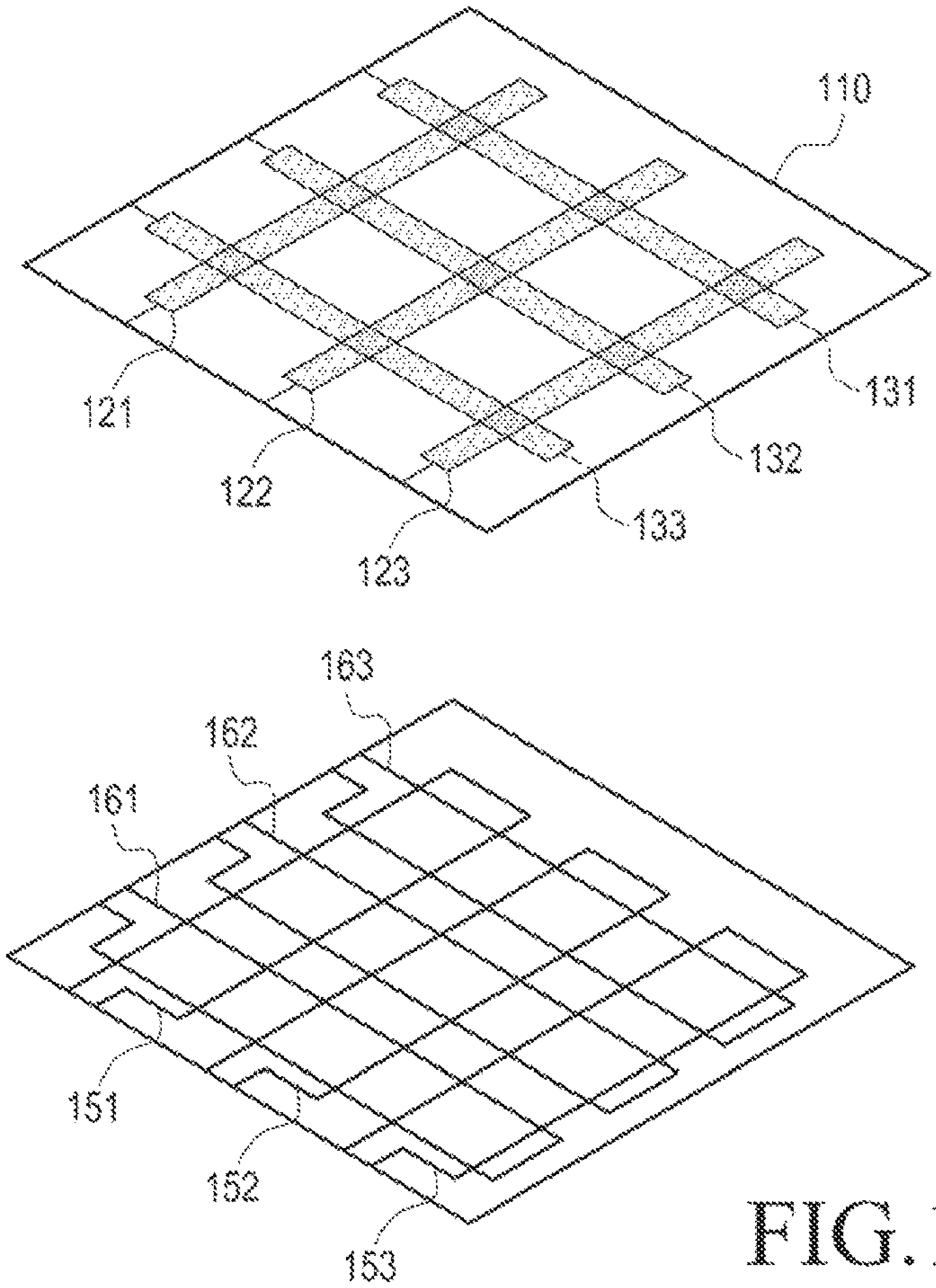

110
121
122
123
131
132
133
163
162
161
151
152
153

FIG.1A

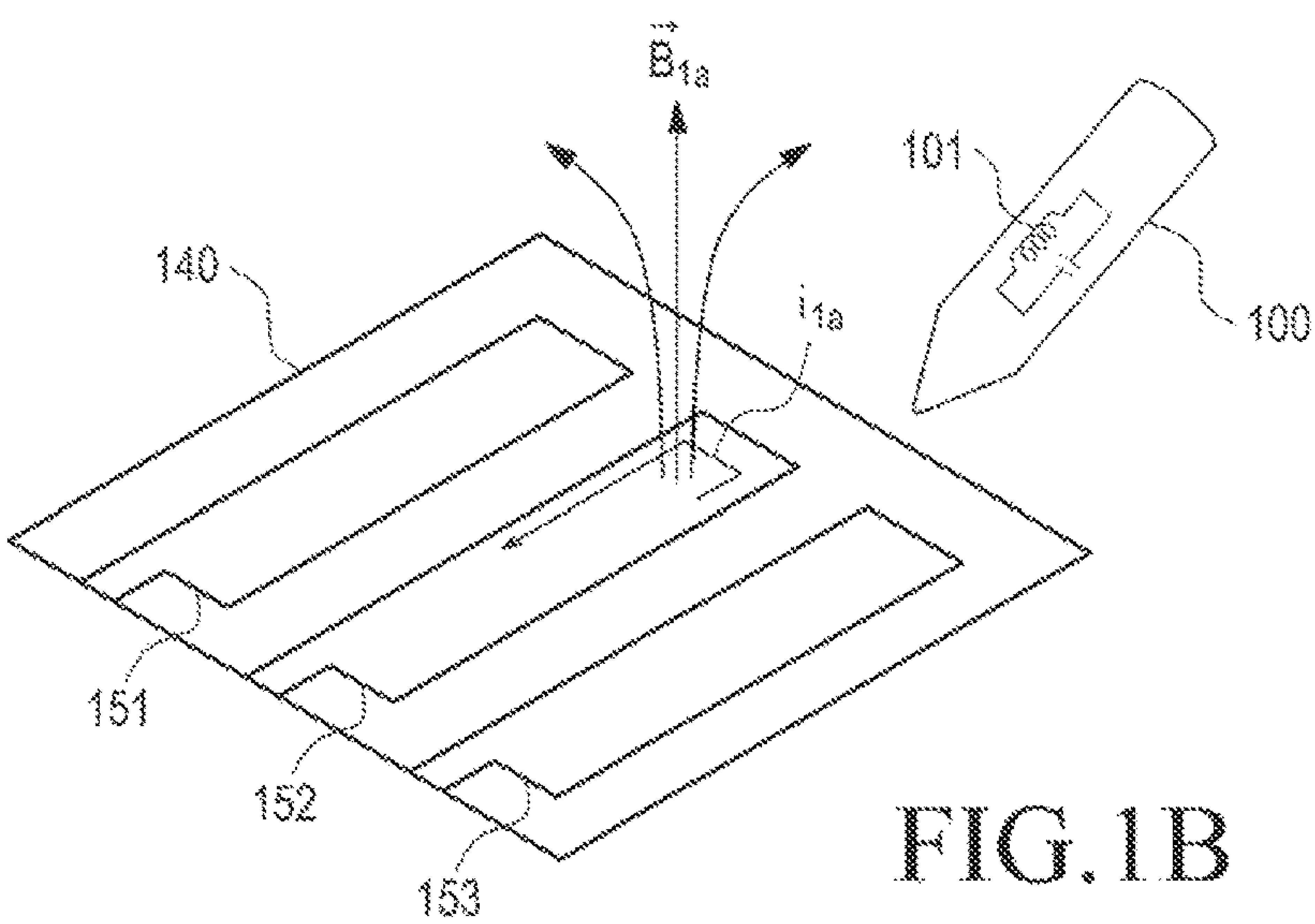
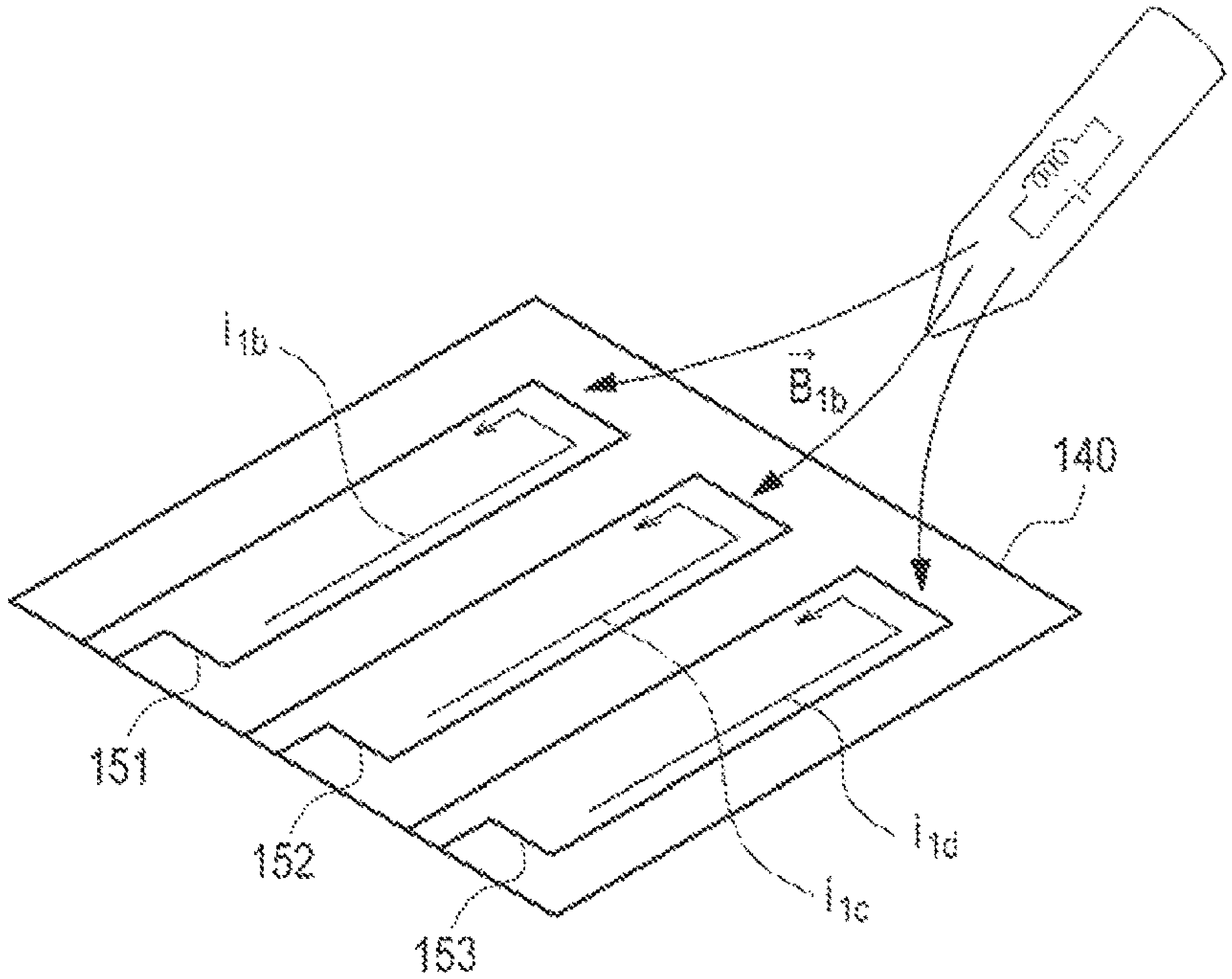
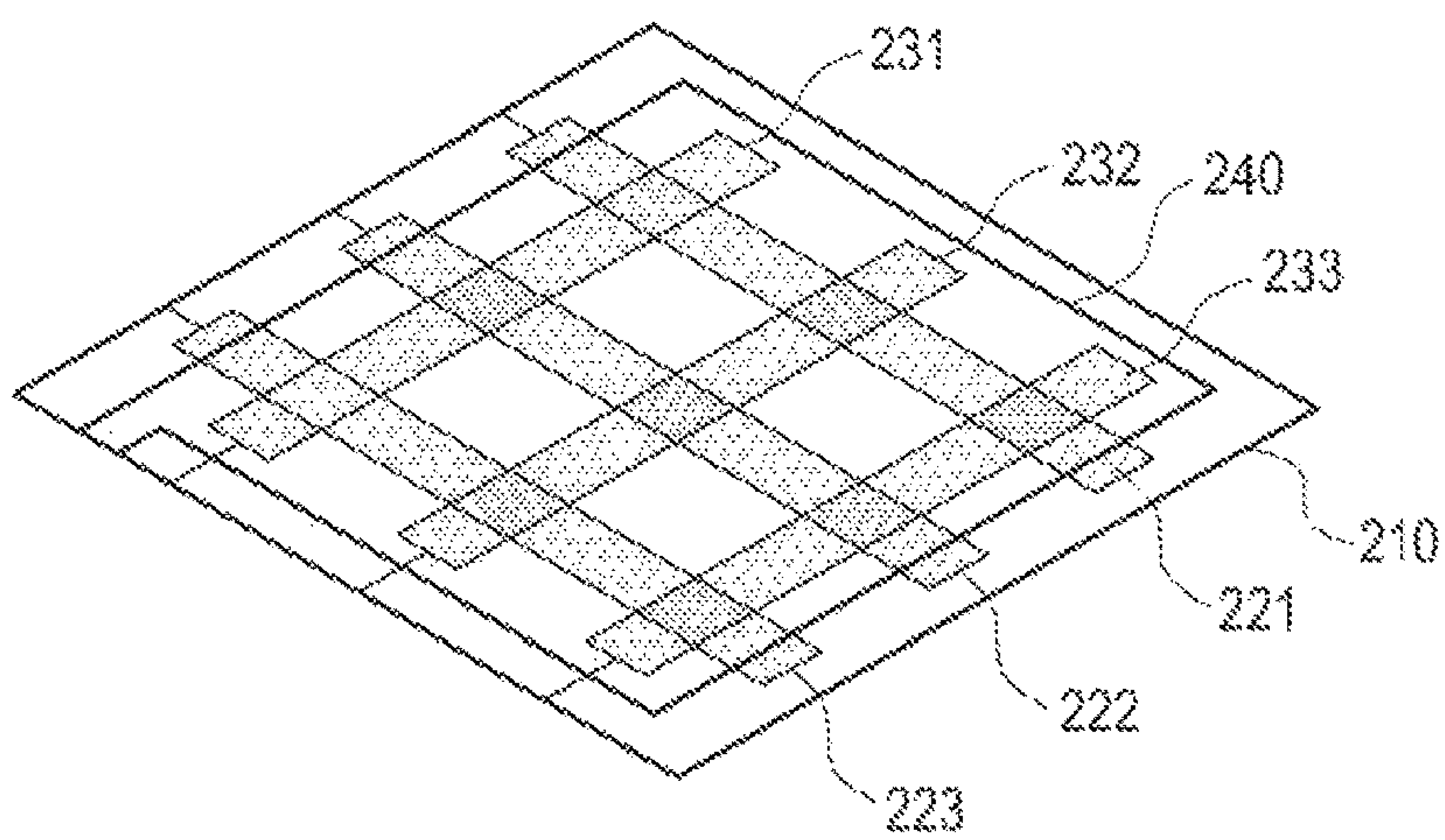

B1a
101
100
140
i1a
151
152
153

FIG.1B



i_{1b}
$\vec{B}_{1b}$
140
151
152
153
i_{1d}
i_{1c}

FIG.1C



231
232
240
233
210
221
222
223

FIG.2A

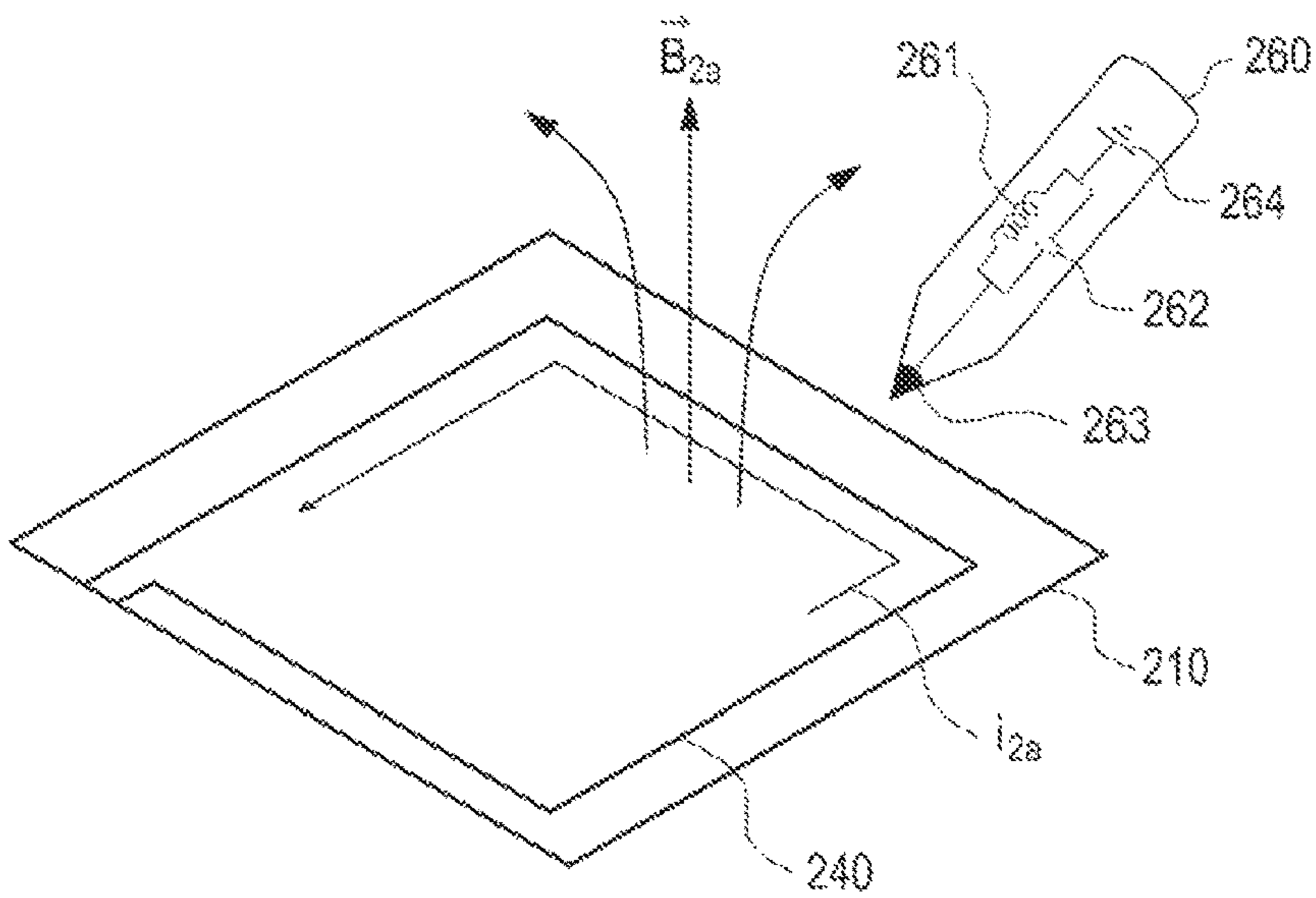

B2a
261
260
264
262
263
210
i2a
240

FIG.2B

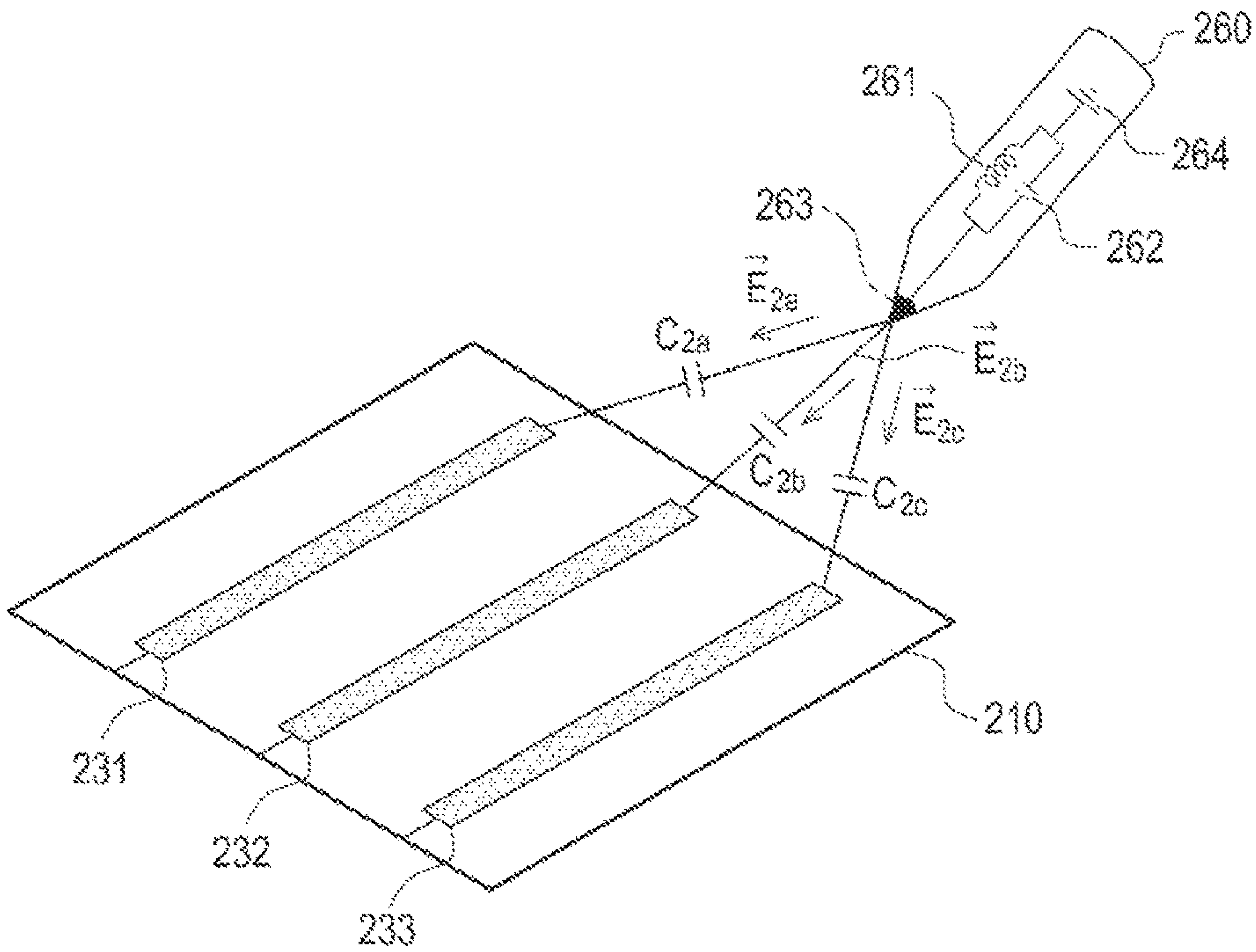

260
261
264
263
262
E2a
C2a
E2b
E2c
C2b
C2c
210
231
232
233

FIG.2C

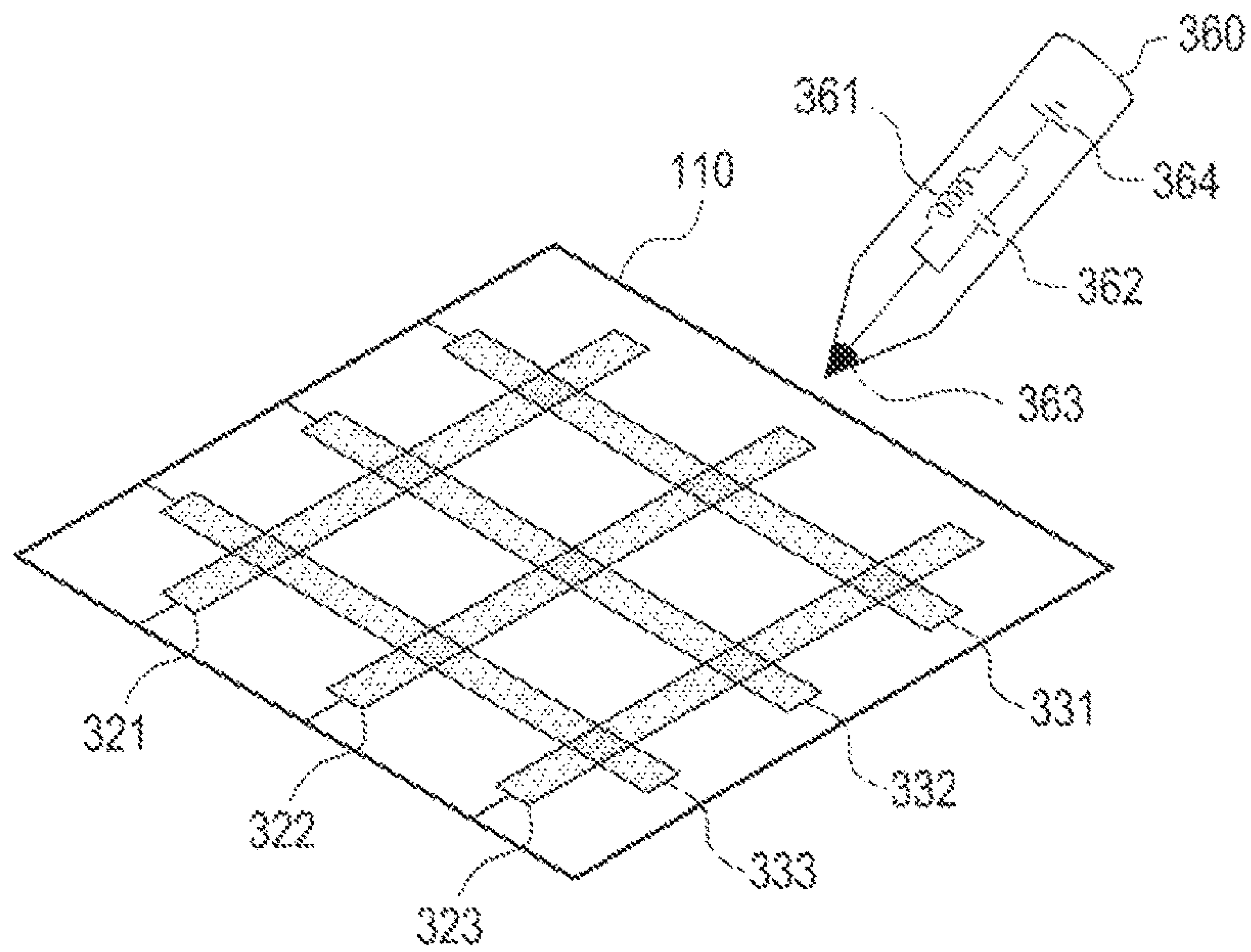

360
361
364
110
362
363
331
321
332
322
333
323

FIG.3

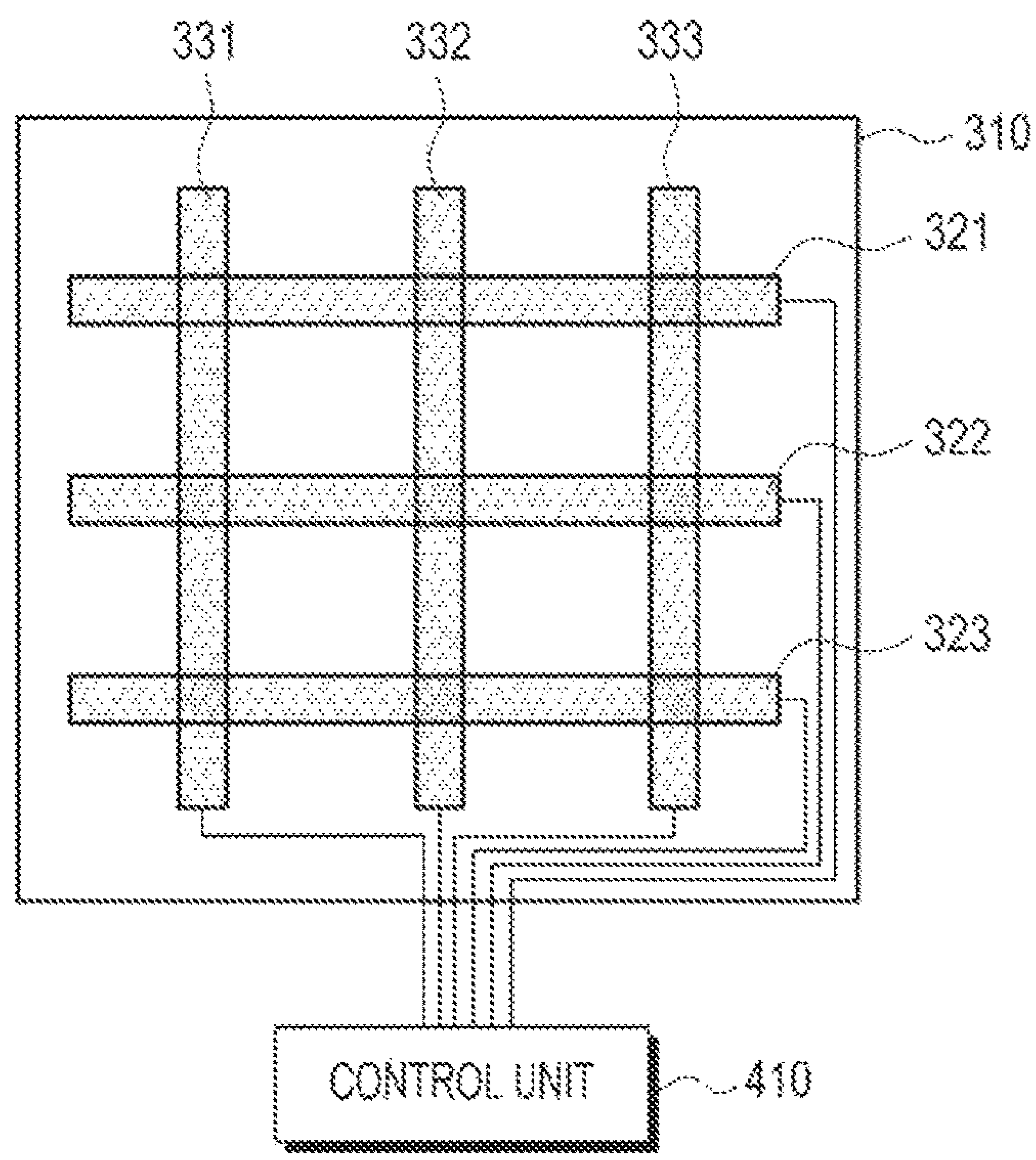

331
332
333
310
321
322
323
CONTROL UNIT
410

FIG.4A

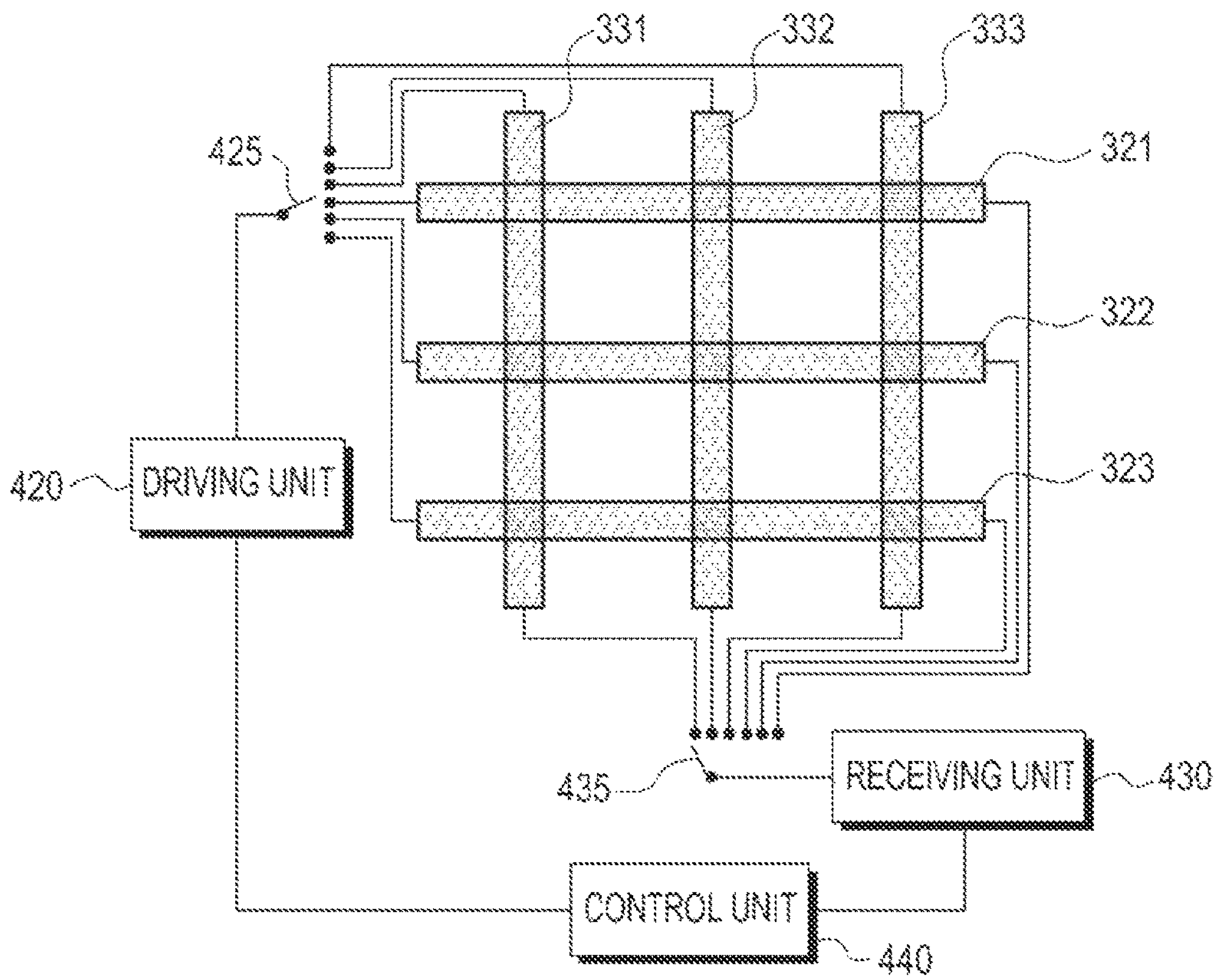
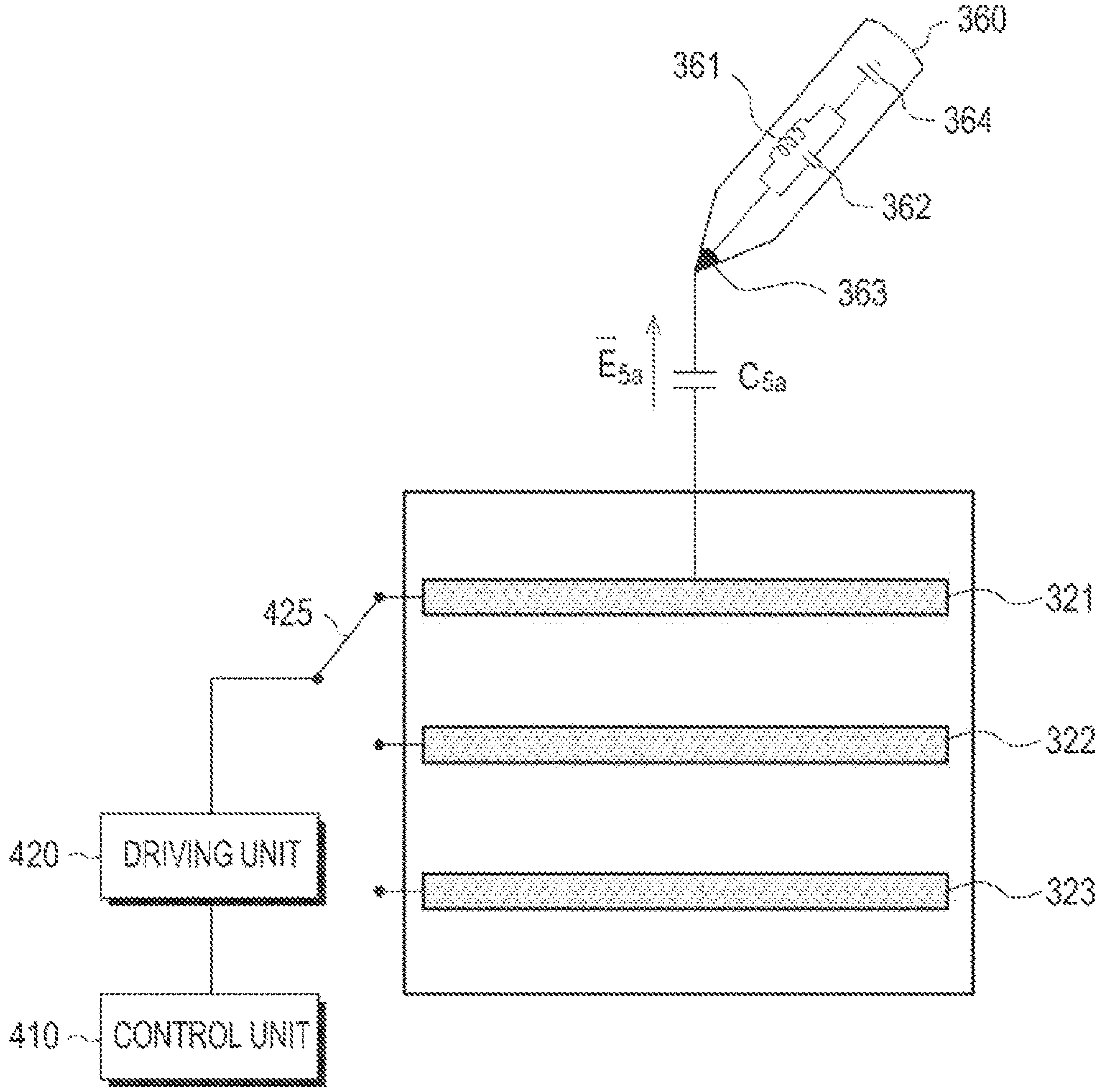

331
332
333
425
321
322
323
420
DRIVING UNIT
435
RECEIVING UNIT
430
CONTROL UNIT
440

FIG.4B



360
361
364
362
363
$\vec{E}_{5a}$
C_{5a}
425
321
322
323
420
DRIVING UNIT
410
CONTROL UNIT

FIG.5A

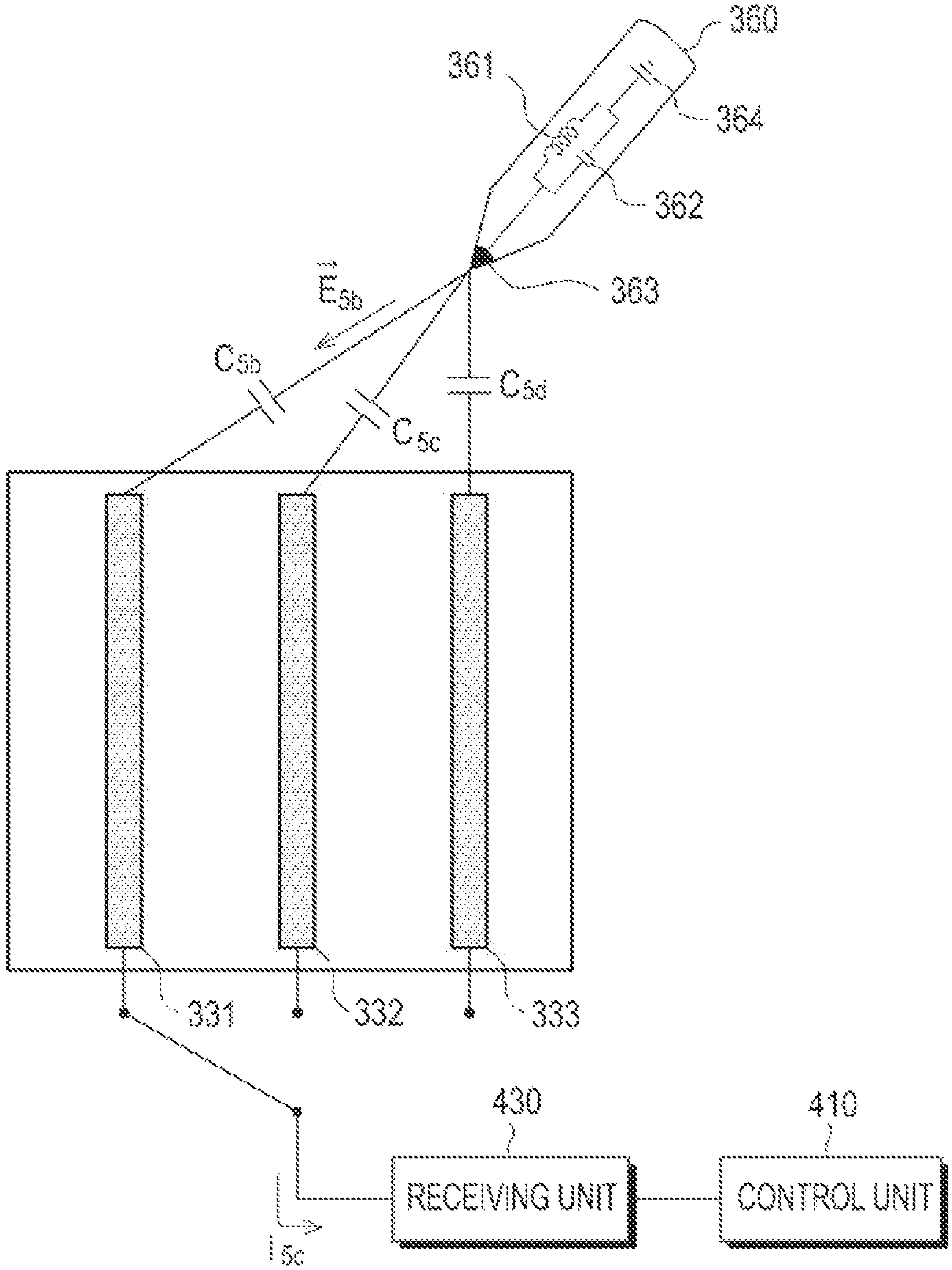

360
361
364
362
363
$\vec{E}_{5b}$
C_{5b}
C_{5c}
C_{5d}
331
332
333
430
410
RECEIVING UNIT
CONTROL UNIT
i_{5c}

FIG.5B

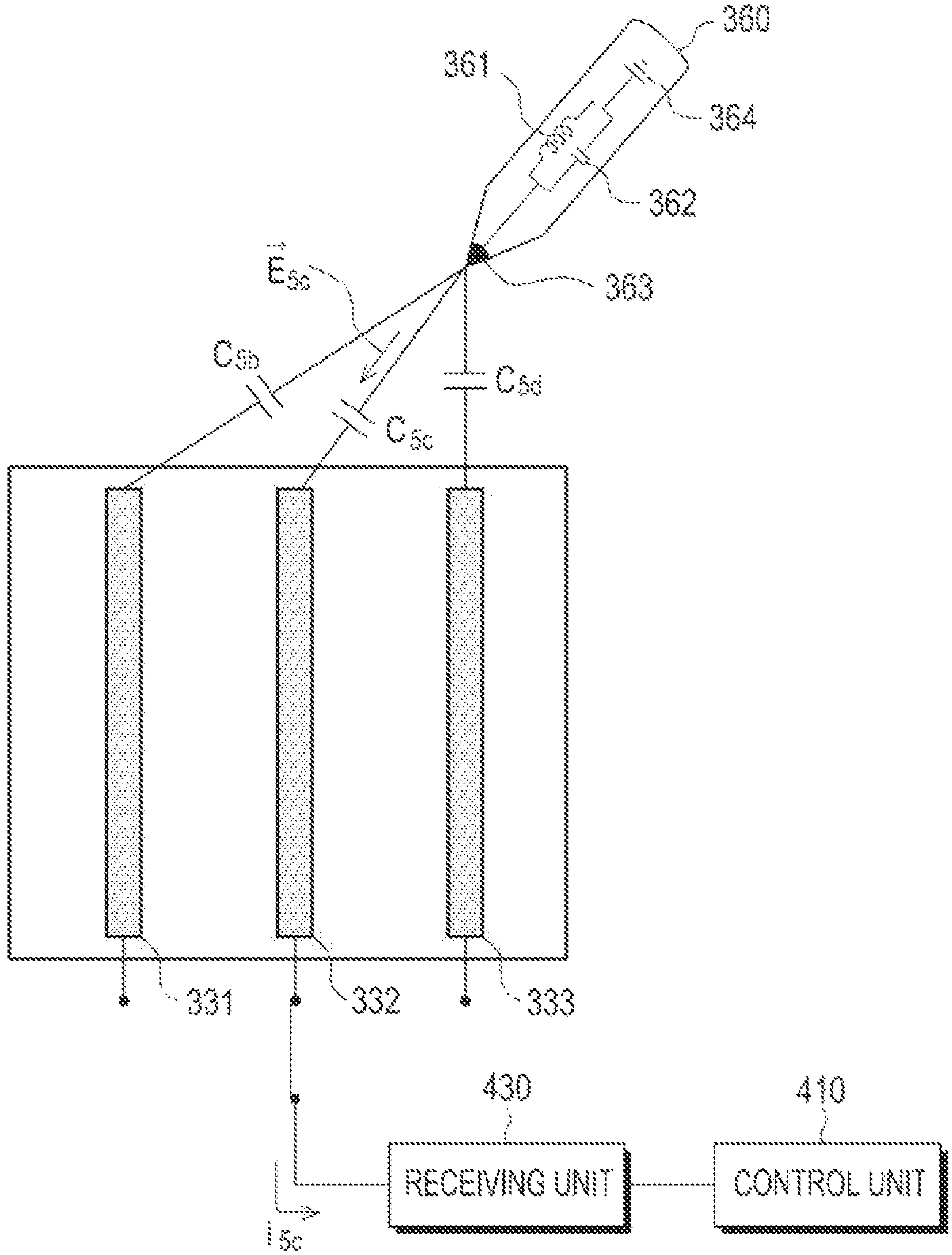

360
361
364
362
363
$\vec{E}_{5c}$
C_{5b}
C_{5d}
C_{5c}
331
332
333
430
410
RECEIVING UNIT
CONTROL UNIT
i_{5c}

FIG.5C

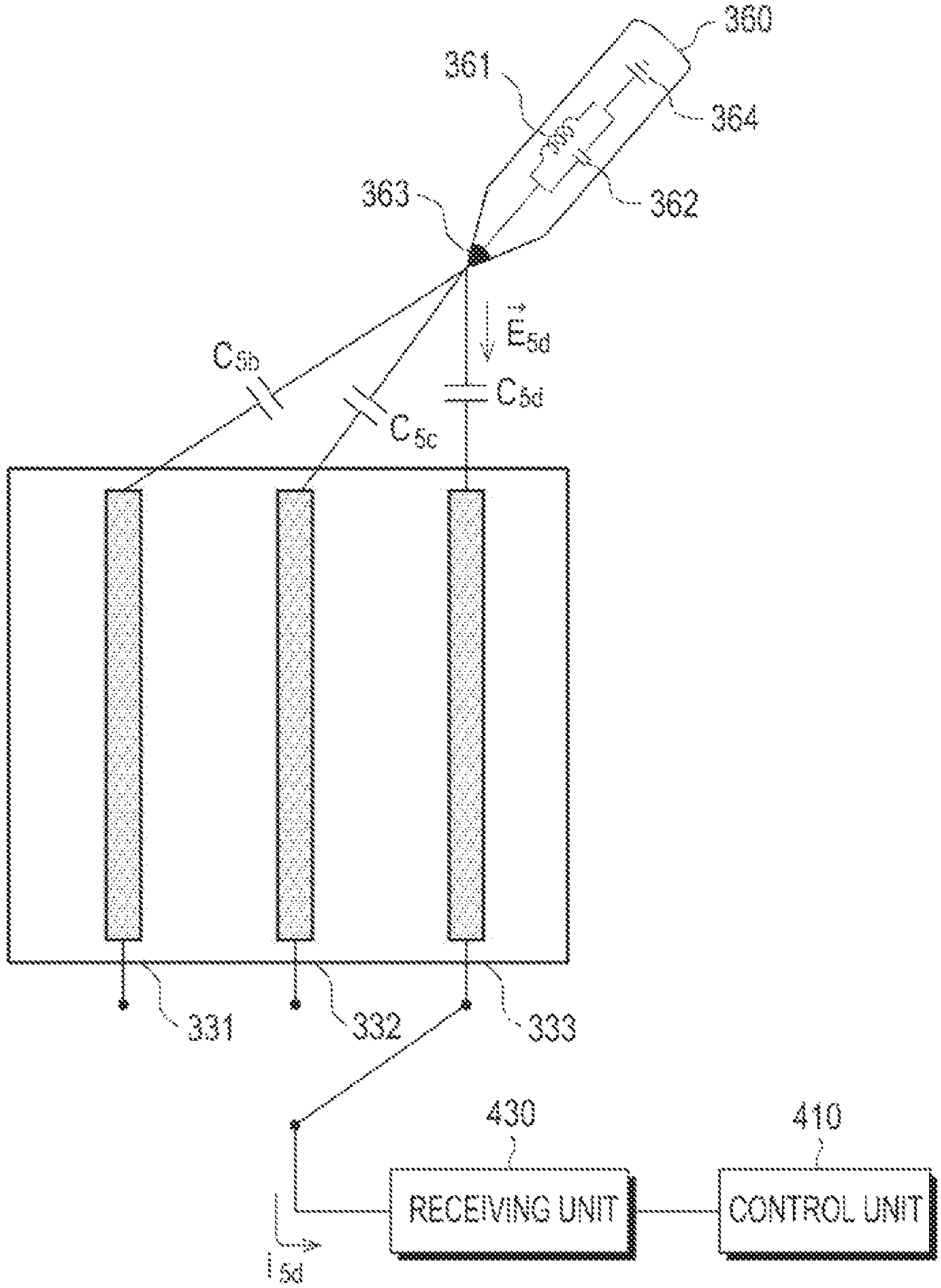

360
361
364
363
362
$\vec{E}_{5d}$
C_{5b}
C_{5c}
C_{5d}
331
332
333
430
410
RECEIVING UNIT
CONTROL UNIT
i_{5d}

FIG.5D

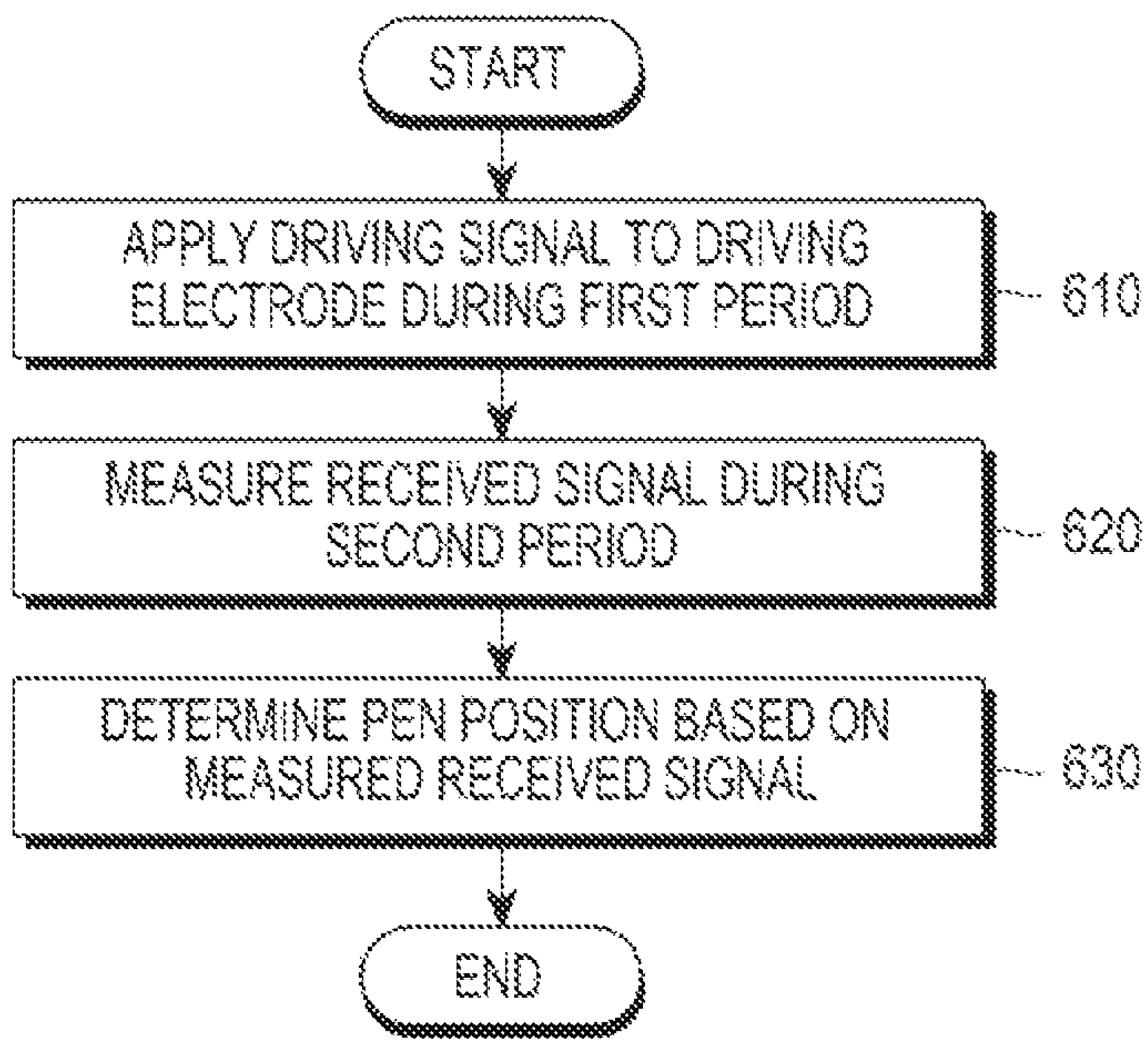

START
APPLY DRIVING SIGNAL TO DRIVING ELECTRODE DURING FIRST PERIOD
610
MEASURE RECEIVED SIGNAL DURING SECOND PERIOD
620
DETERMINE PEN POSITION BASED ON MEASURED RECEIVED SIGNAL
630
END

FIG.6

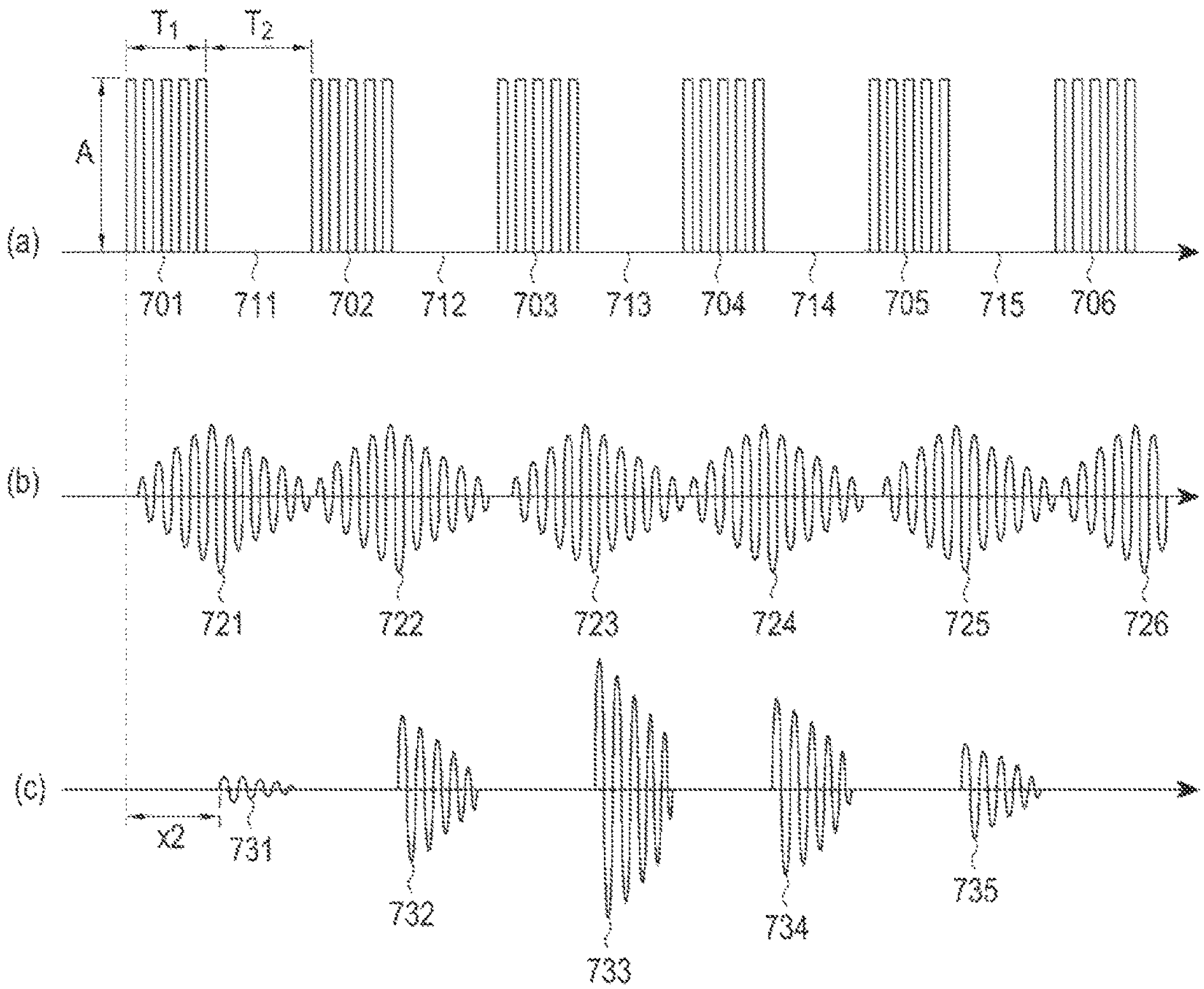

T1
T2
A
(a)
701
711
702
712
703
713
704
714
705
715
706
(b)
721
722
723
724
725
726
(c)
x2
731
732
733
734
735

FIG.7

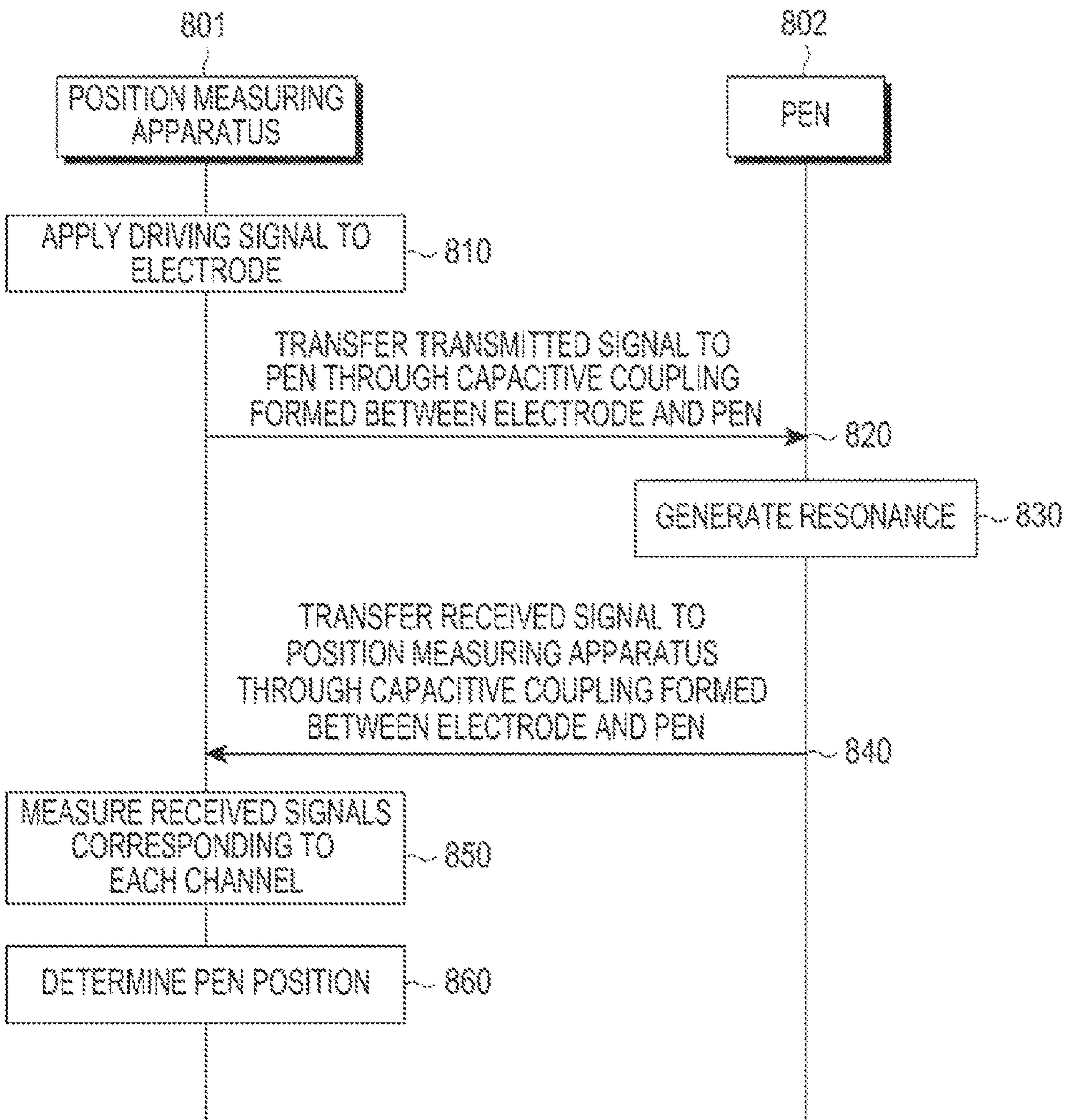

801
POSITION MEASURING APPARATUS
802
PEN
APPLY DRIVING SIGNAL TO ELECTRODE
810
TRANSFER TRANSMITTED SIGNAL TO PEN THROUGH CAPACITIVE COUPLING FORMED BETWEEN ELECTRODE AND PEN
820
GENERATE RESONANCE
830
TRANSFER RECEIVED SIGNAL TO POSITION MEASURING APPARATUS THROUGH CAPACITIVE COUPLING FORMED BETWEEN ELECTRODE AND PEN
840
MEASURE RECEIVED SIGNALS CORRESPONDING TO EACH CHANNEL
850
DETERMINE PEN POSITION
860

FIG.8

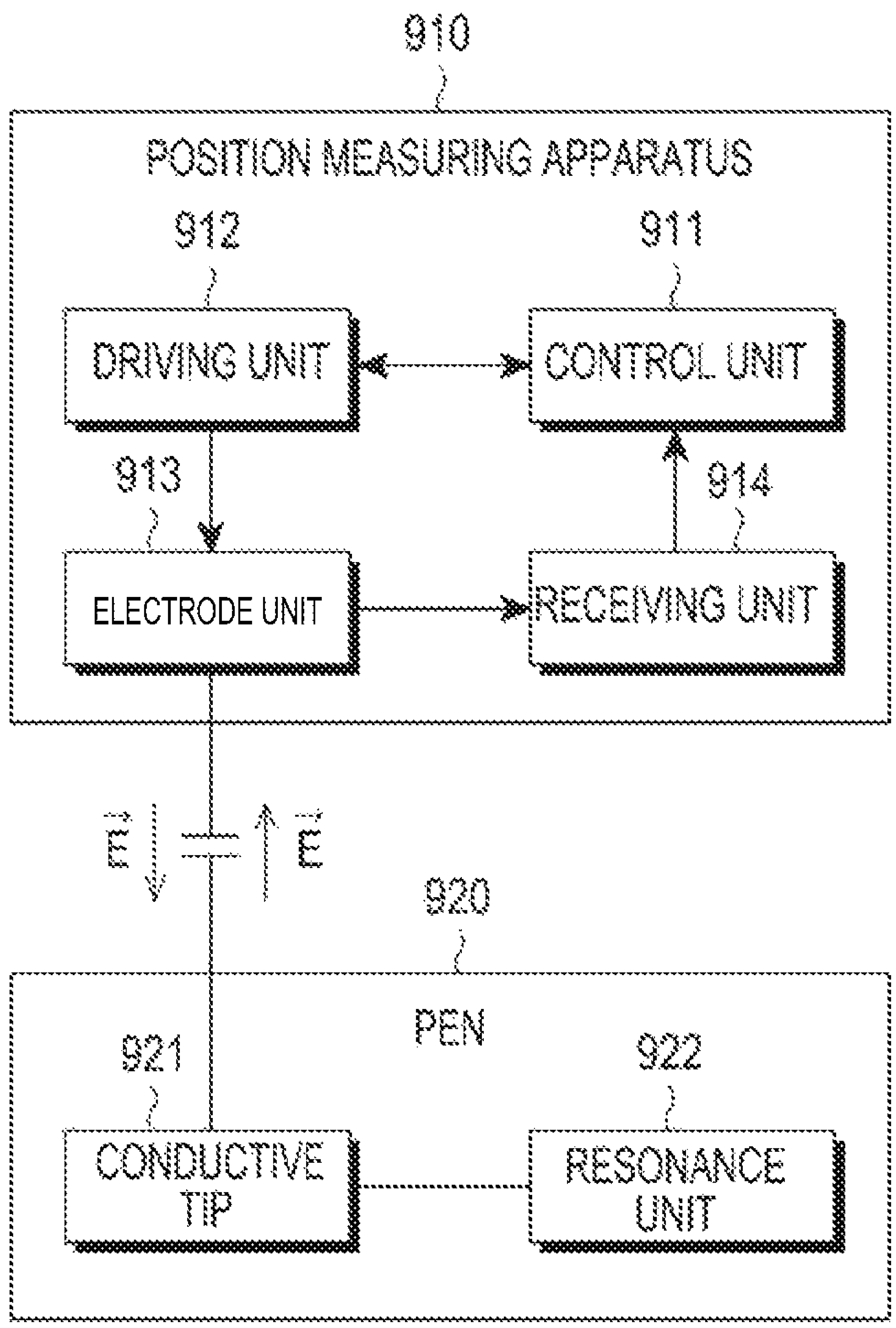

910
POSITION MEASURING APPARATUS
912
911
DRIVING UNIT
CONTROL UNIT
913
914
ELECTRODE UNIT
RECEIVING UNIT
E
E
920
PEN
921
922
CONDUCTIVE TIP
RESONANCE UNIT

FIG.9

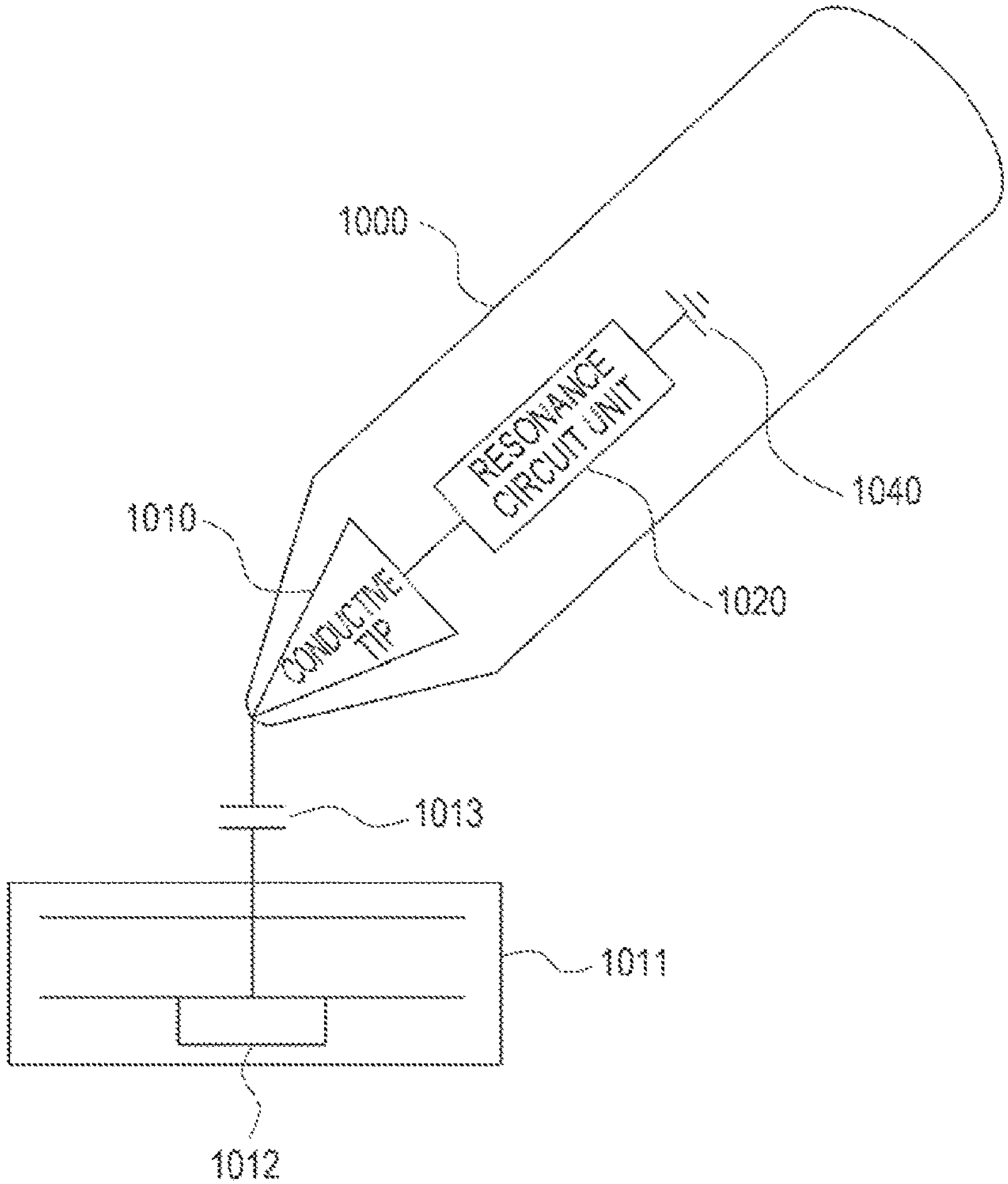


FIG.10A

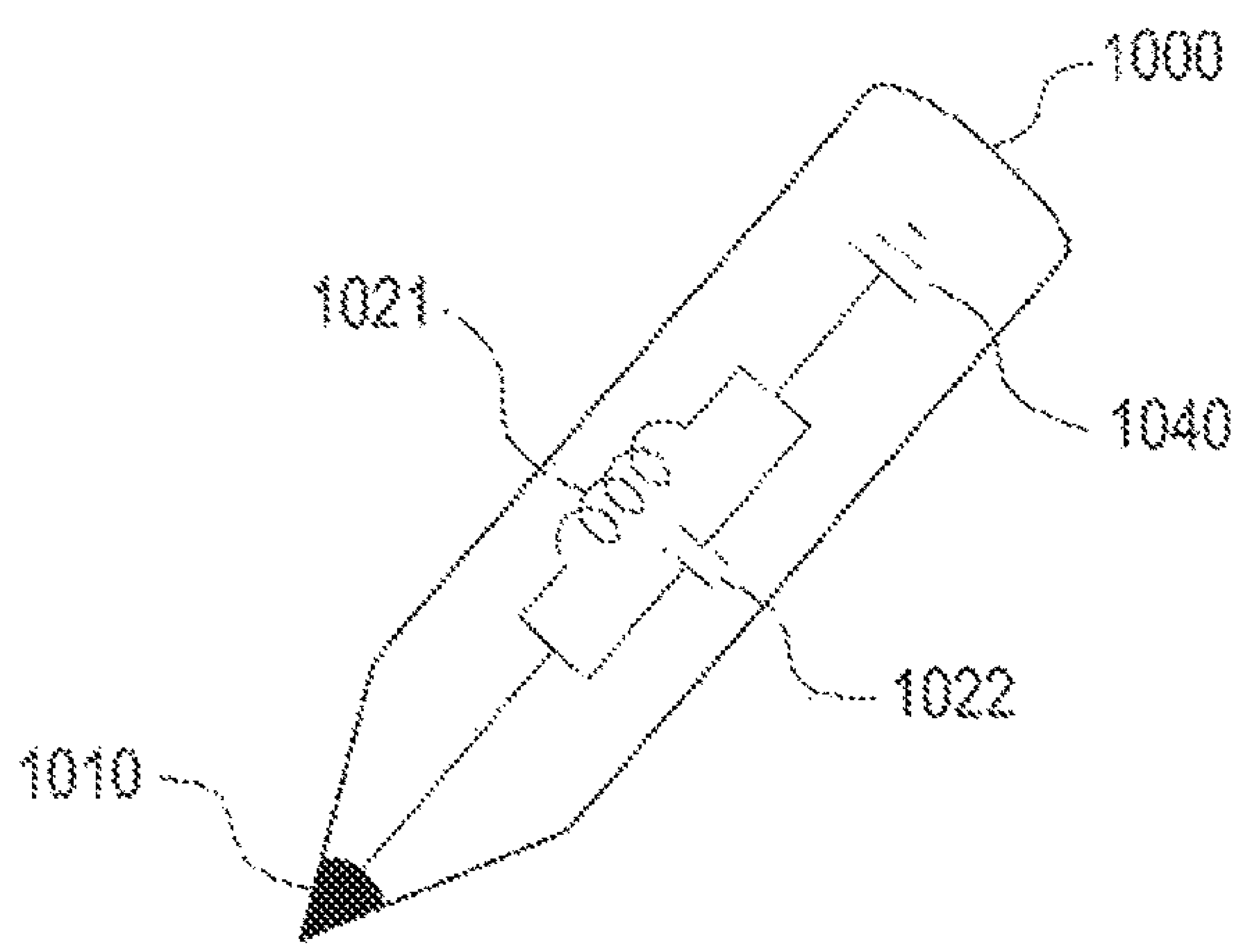


FIG.10B

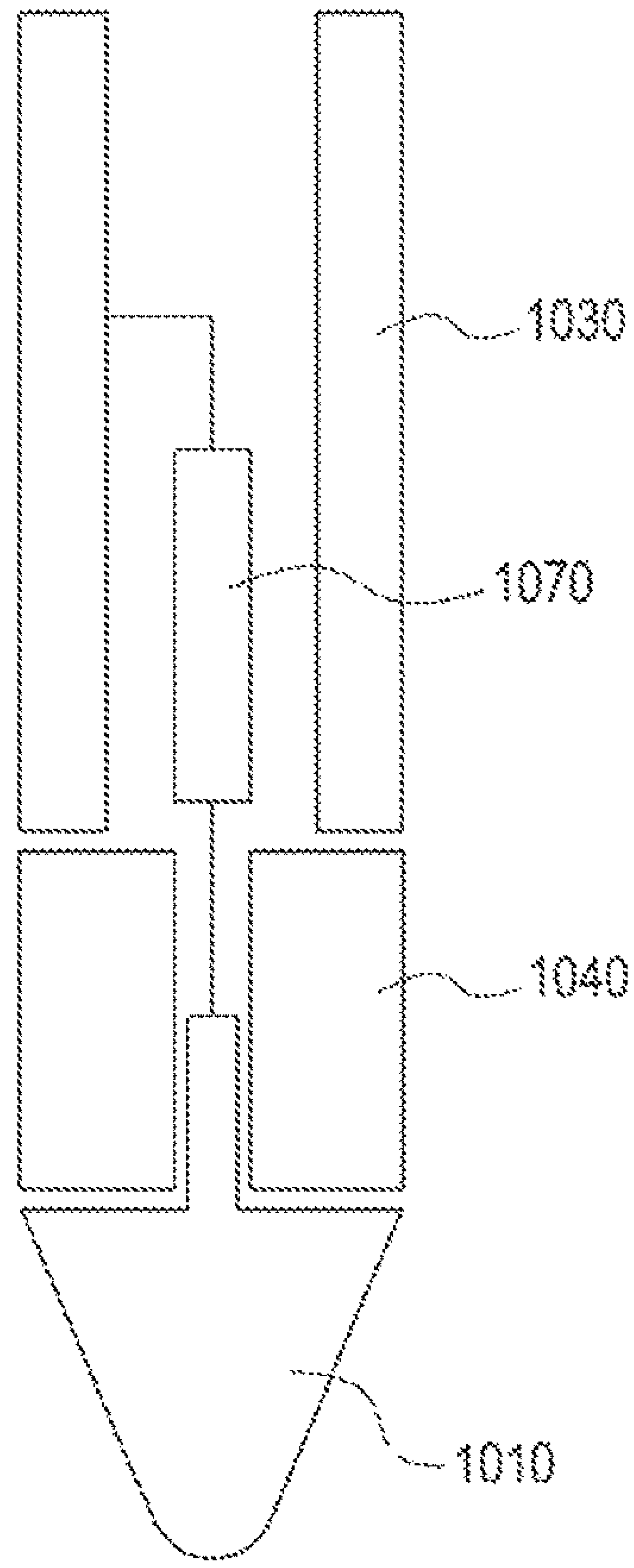


FIG.10C

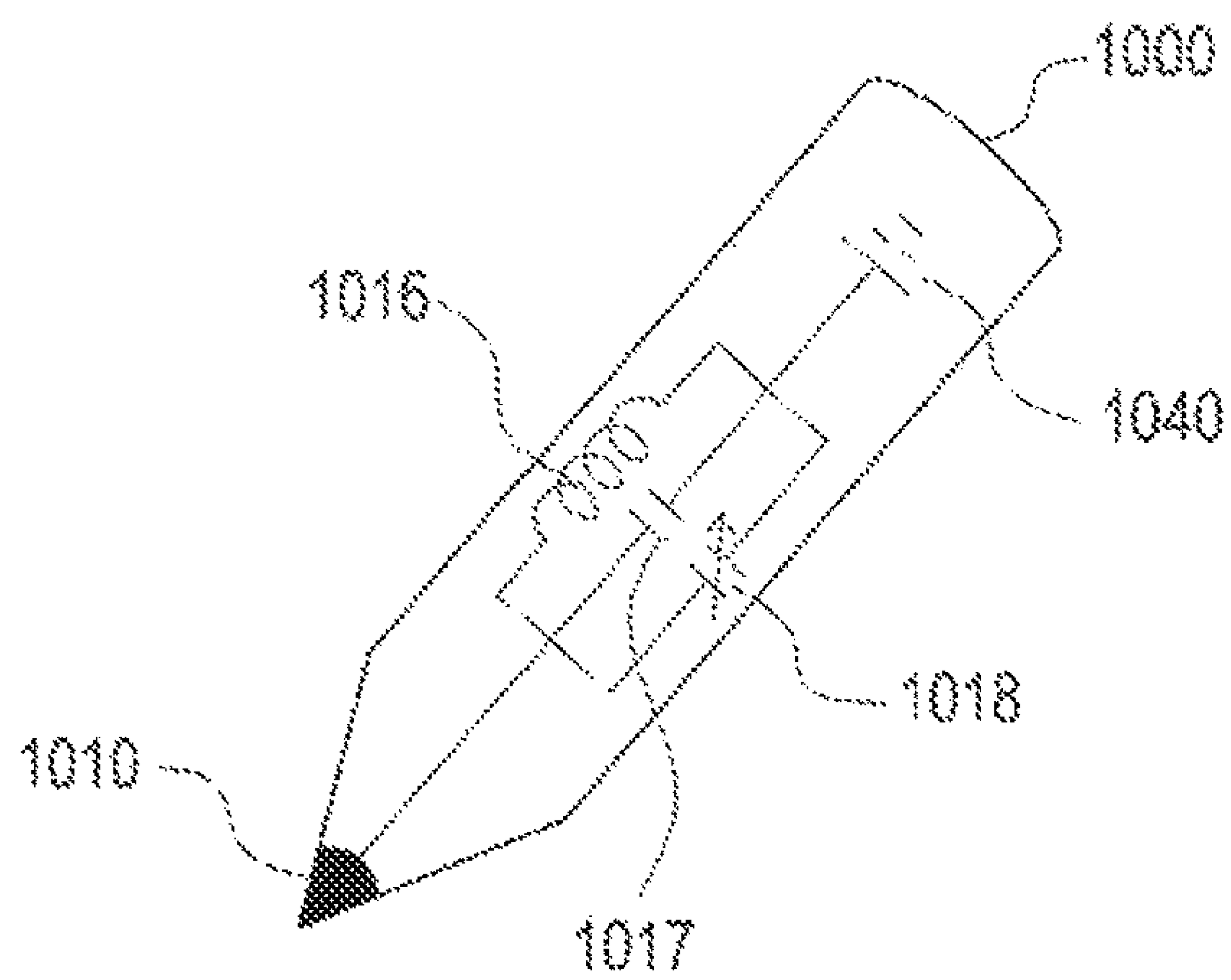


FIG.10D

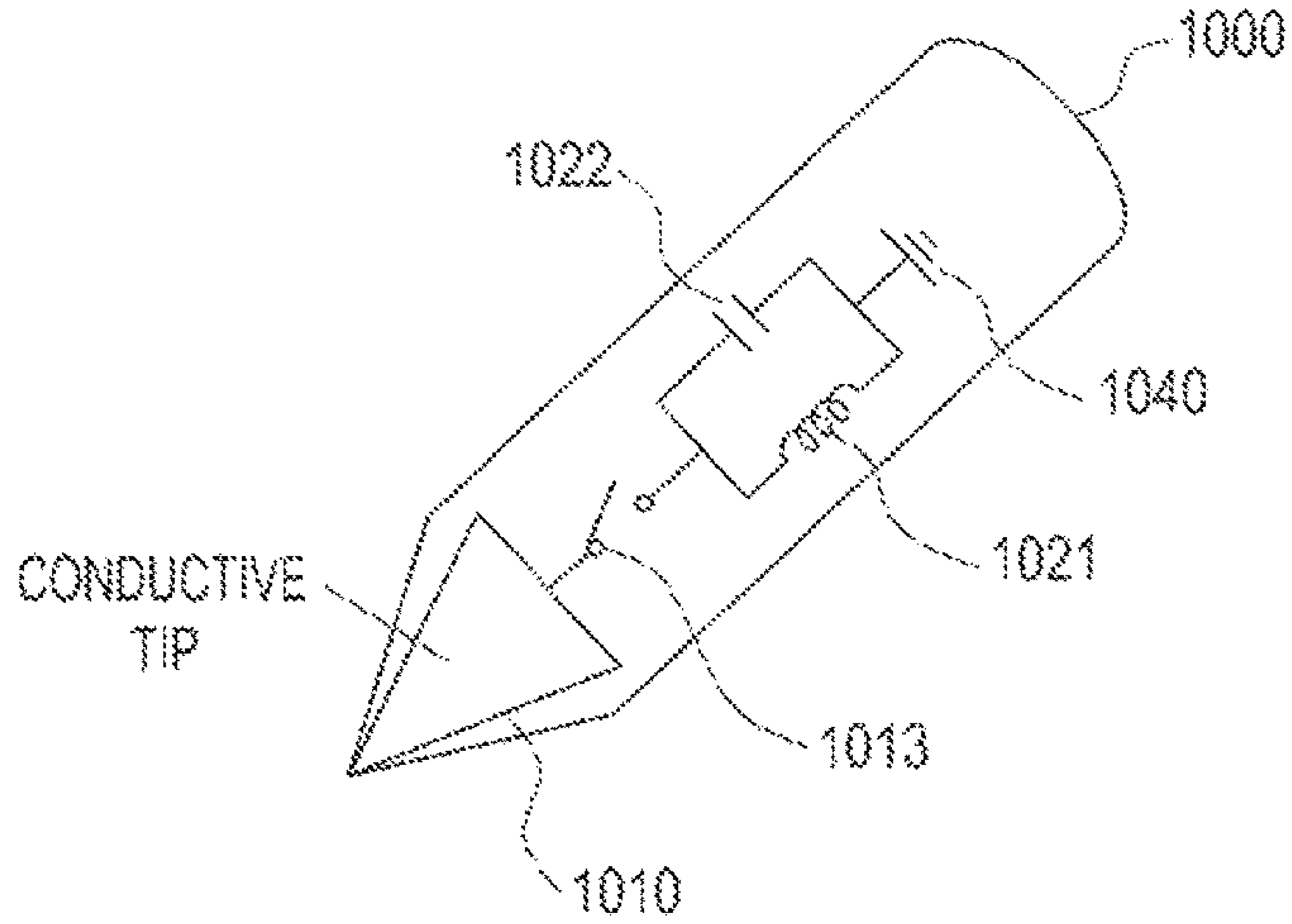


FIG.10E

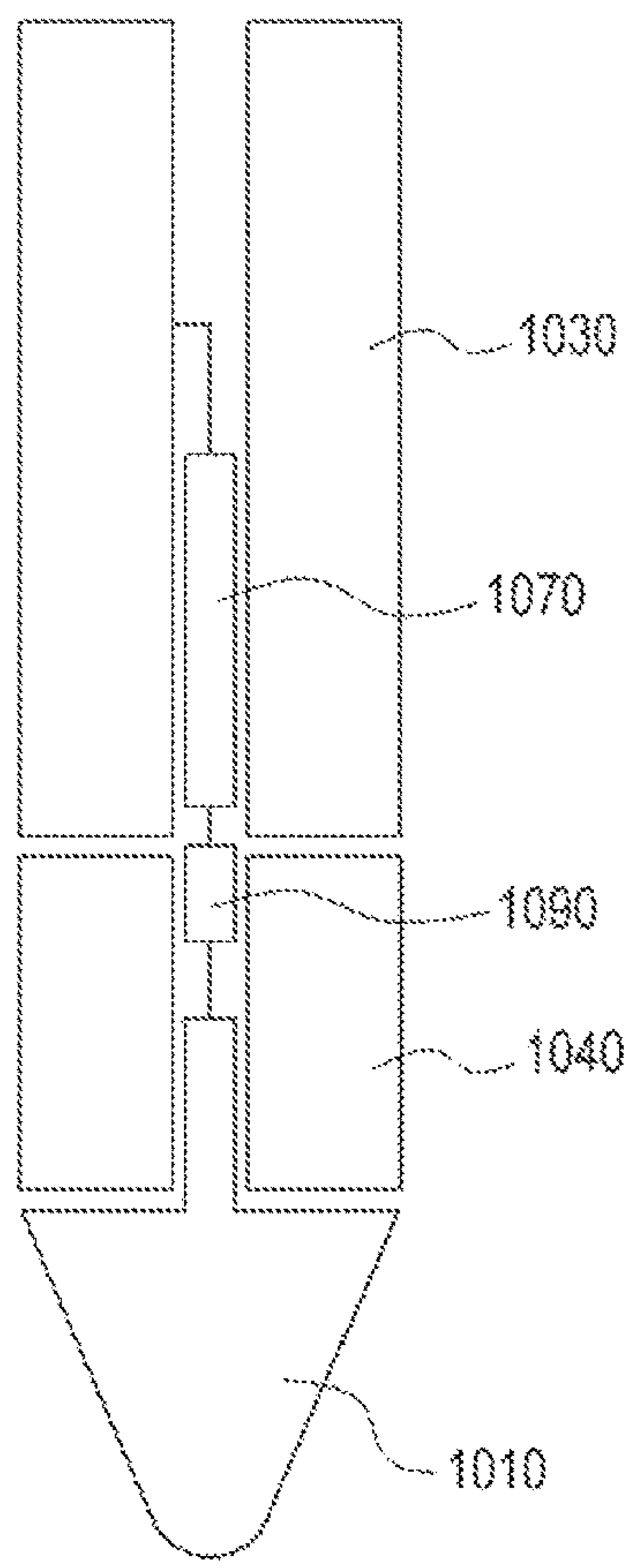


FIG.10F

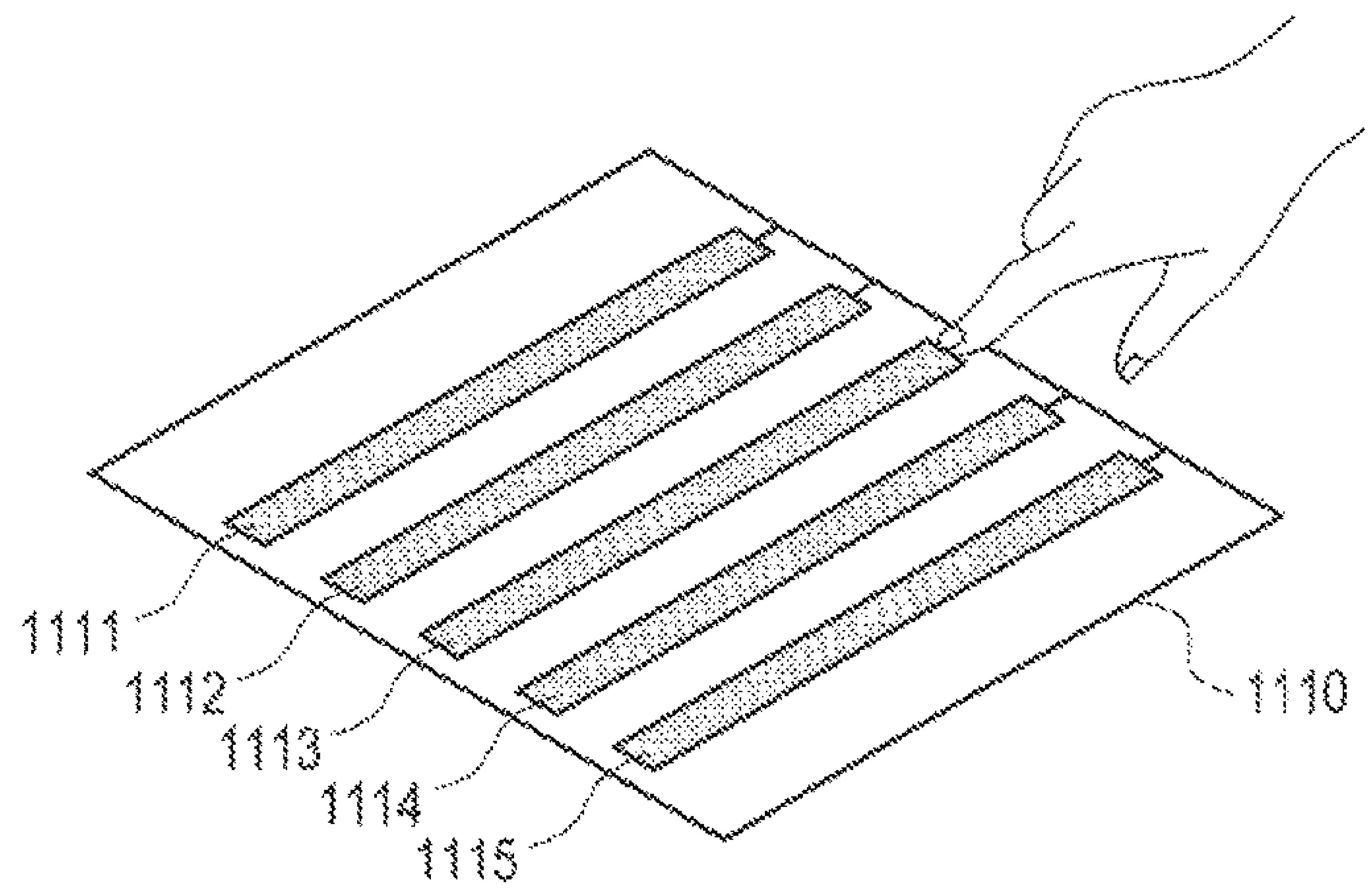


FIG.11A

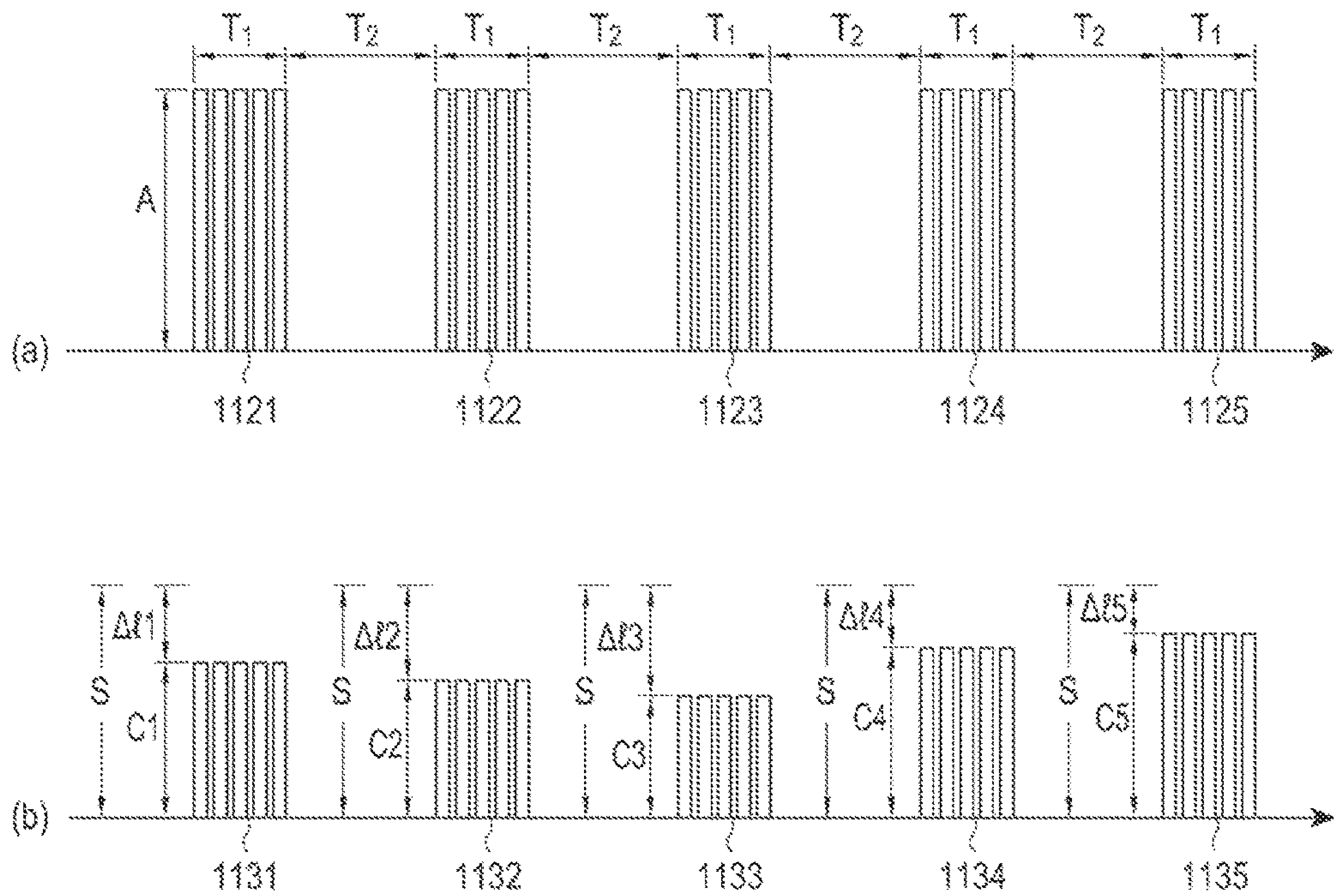


FIG.11B

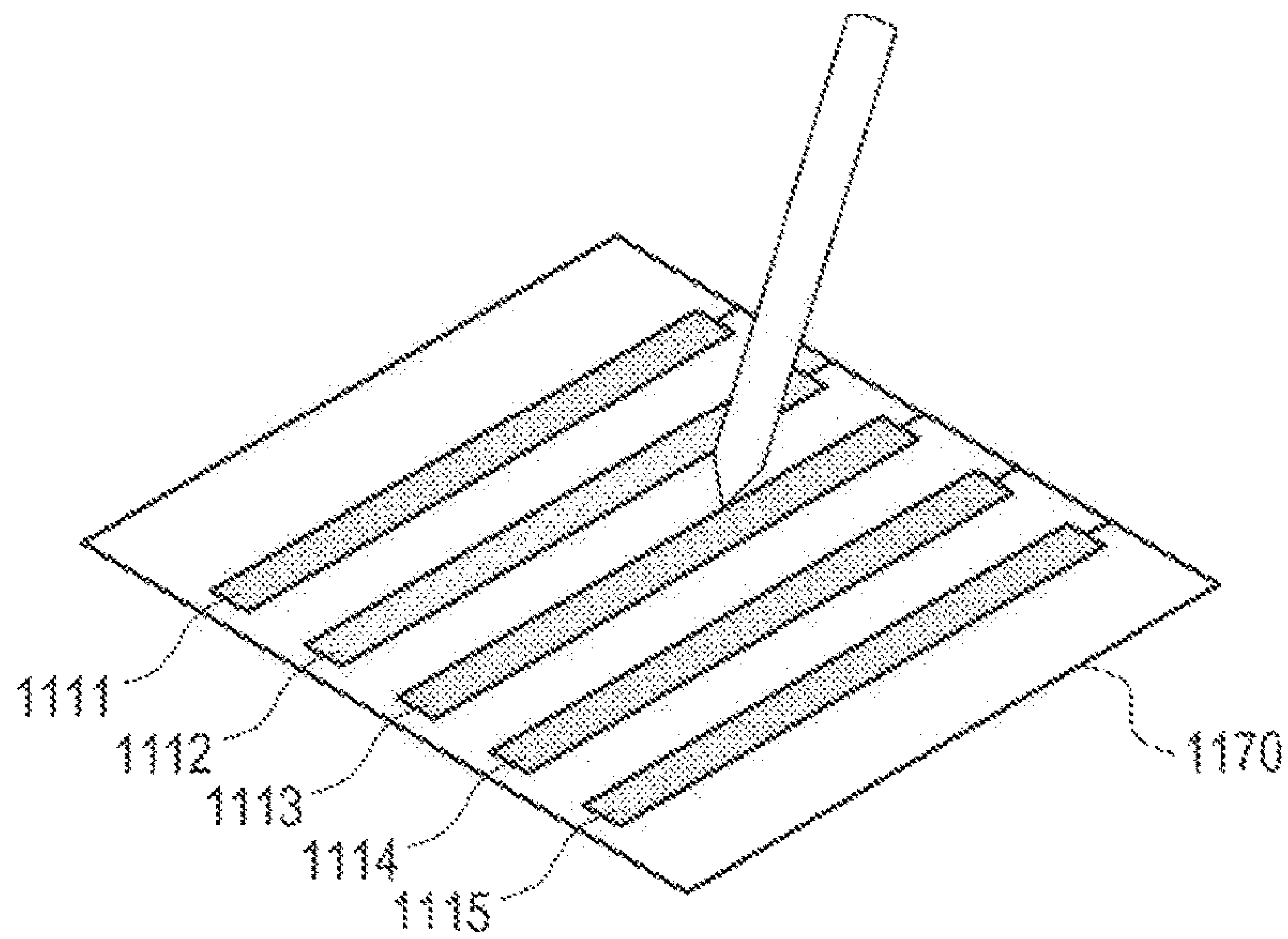


FIG.12A

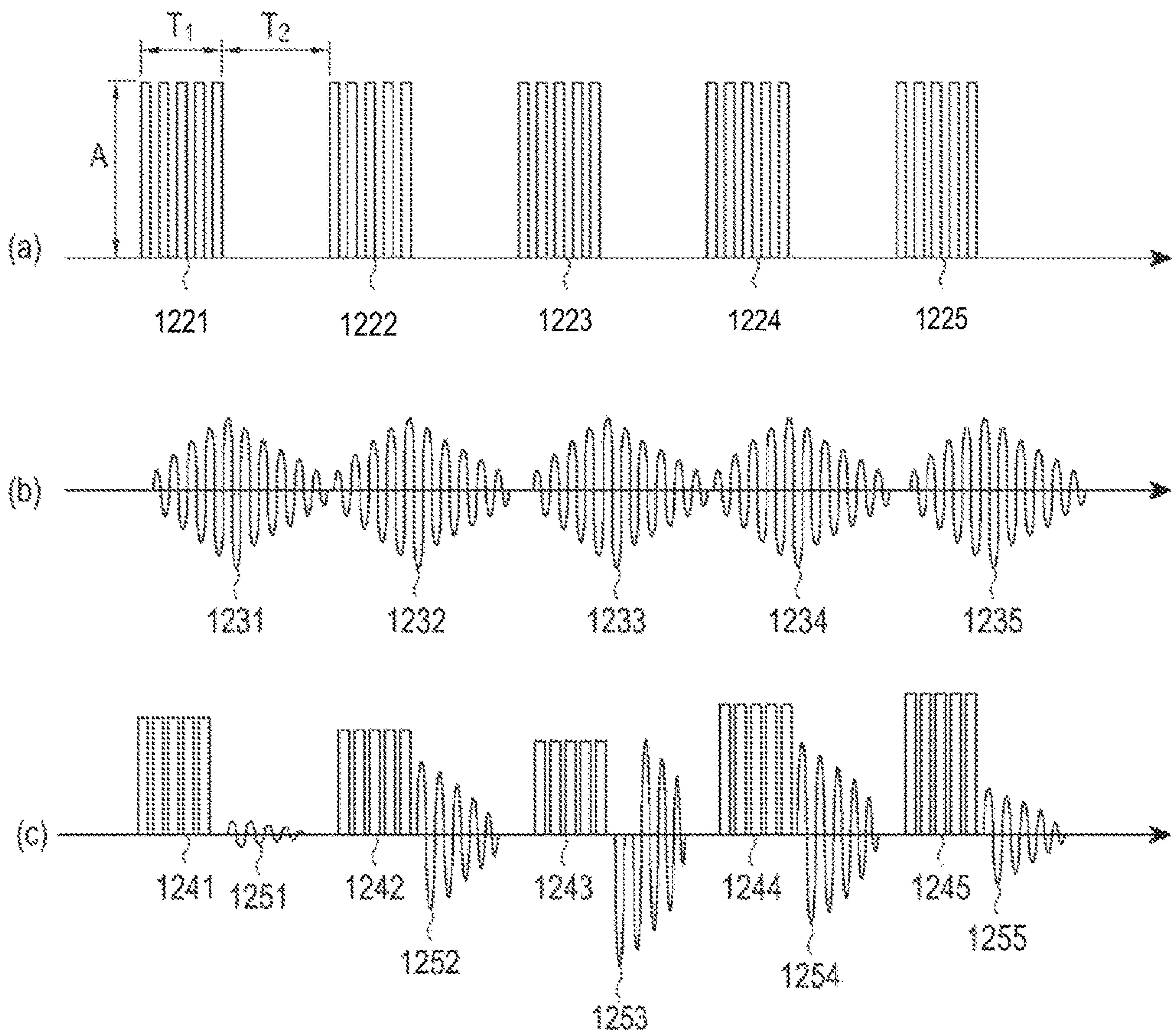

T1
T2
A
(a)
1221
1222
1223
1224
1225
(b)
1231
1232
1233
1234
1235
(c)
1241
1251
1242
1252
1243
1253
1244
1254
1245
1255

FIG.12B

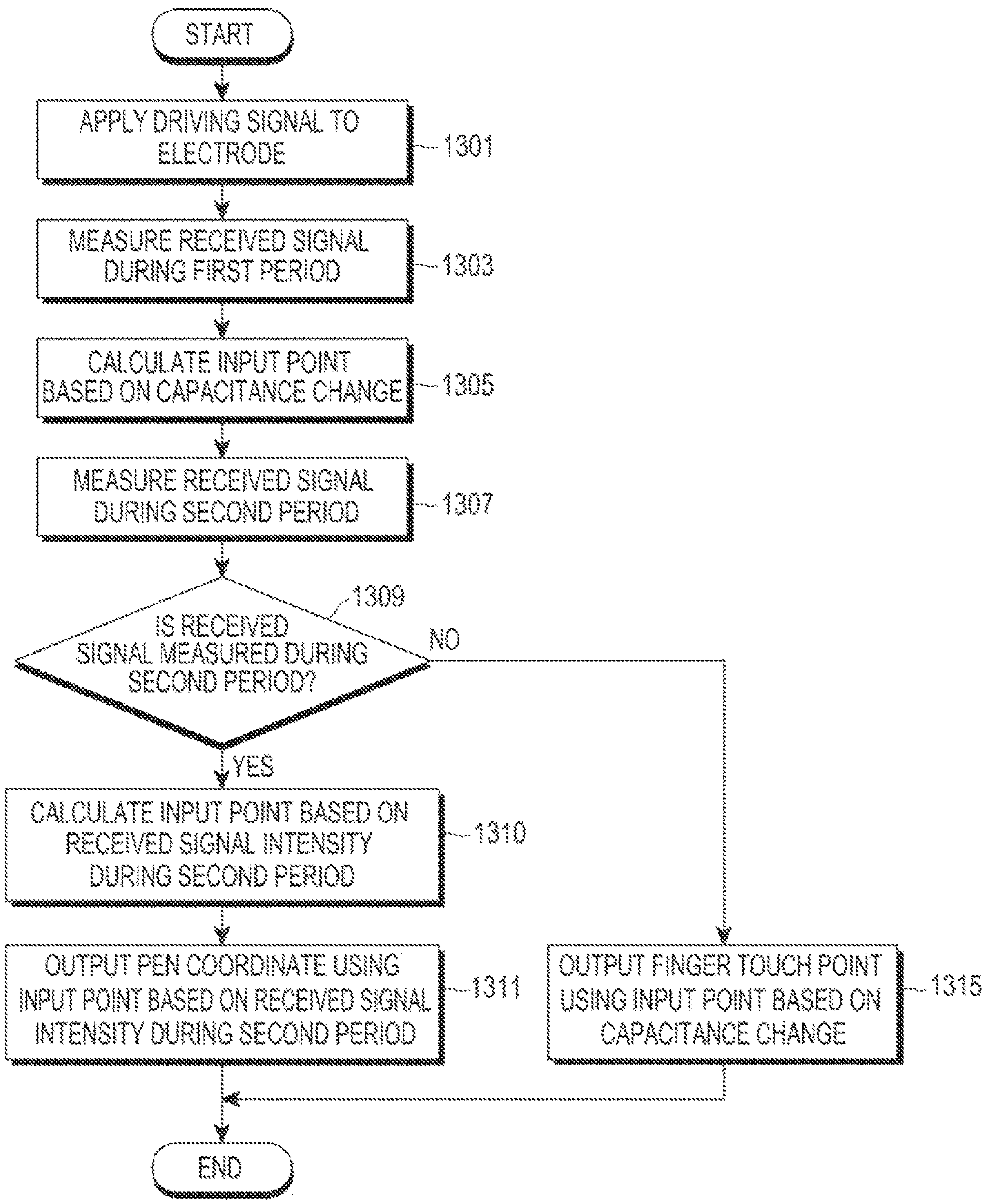

START
APPLY DRIVING SIGNAL TO ELECTRODE
1301
MEASURE RECEIVED SIGNAL DURING FIRST PERIOD
1303
CALCULATE INPUT POINT BASED ON CAPACITANCE CHANGE
1305
MEASURE RECEIVED SIGNAL DURING SECOND PERIOD
1307
1309
IS RECEIVED SIGNAL MEASURED DURING SECOND PERIOD?
NO
YES
CALCULATE INPUT POINT BASED ON RECEIVED SIGNAL INTENSITY DURING SECOND PERIOD
1310
OUTPUT PEN COORDINATE USING INPUT POINT BASED ON RECEIVED SIGNAL INTENSITY DURING SECOND PERIOD
1311
OUTPUT FINGER TOUCH POINT USING INPUT POINT BASED ON CAPACITANCE CHANGE
1315
END

FIG.13A

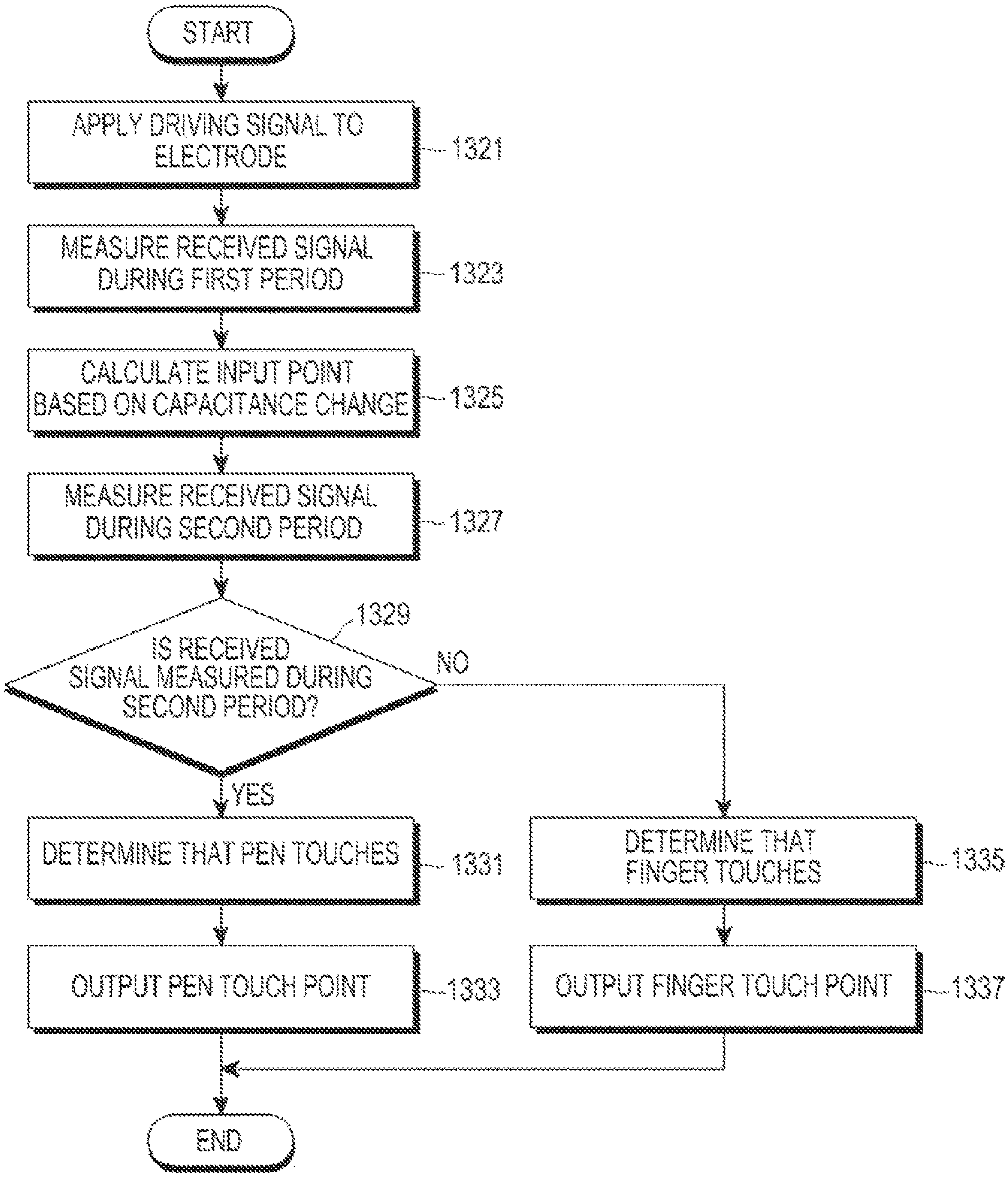

START
APPLY DRIVING SIGNAL TO ELECTRODE
1321
MEASURE RECEIVED SIGNAL DURING FIRST PERIOD
1323
CALCULATE INPUT POINT BASED ON CAPACITANCE CHANGE
1325
MEASURE RECEIVED SIGNAL DURING SECOND PERIOD
1327
1329
IS RECEIVED SIGNAL MEASURED DURING SECOND PERIOD?
NO
YES
DETERMINE THAT PEN TOUCHES
1331
DETERMINE THAT FINGER TOUCHES
1335
OUTPUT PEN TOUCH POINT
1333
OUTPUT FINGER TOUCH POINT
1337
END

FIG.13B

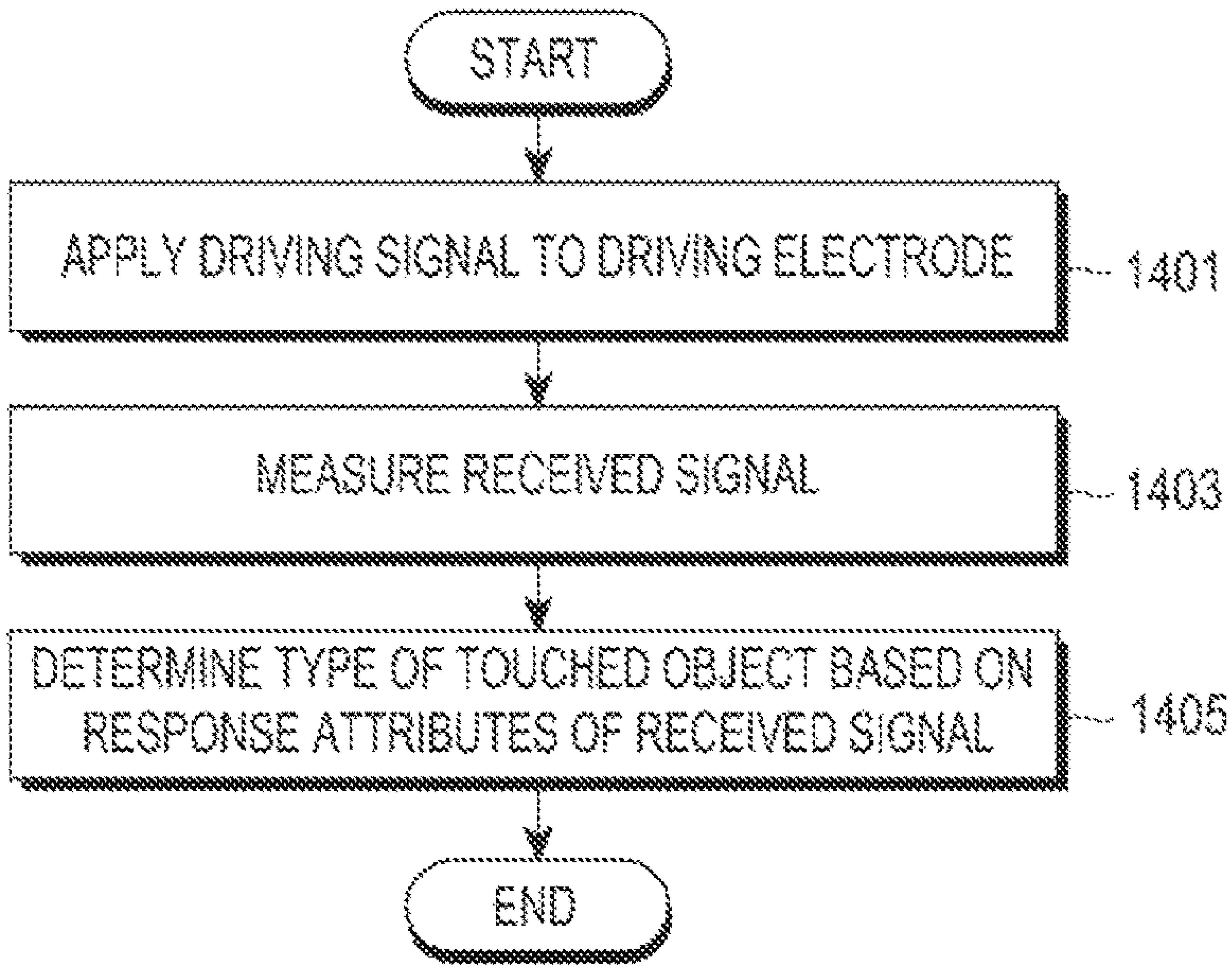

START
APPLY DRIVING SIGNAL TO DRIVING ELECTRODE
1401
MEASURE RECEIVED SIGNAL
1403
DETERMINE TYPE OF TOUCHED OBJECT BASED ON RESPONSE ATTRIBUTES OF RECEIVED SIGNAL
1405
END

FIG.14

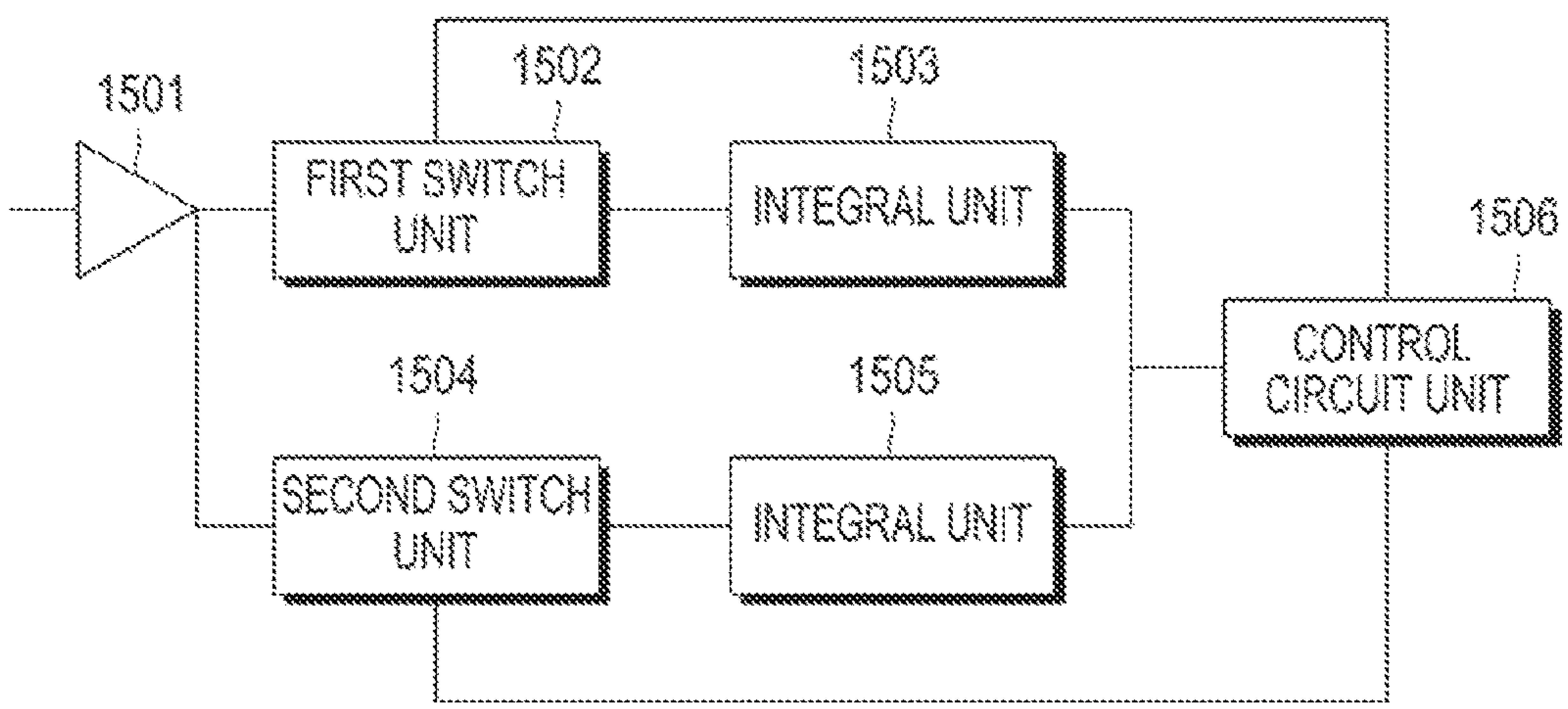

1501
1502
FIRST SWITCH UNIT
1503
INTEGRAL UNIT
1506
CONTROL CIRCUIT UNIT
1504
SECOND SWITCH UNIT
1505
INTEGRAL UNIT

FIG.15

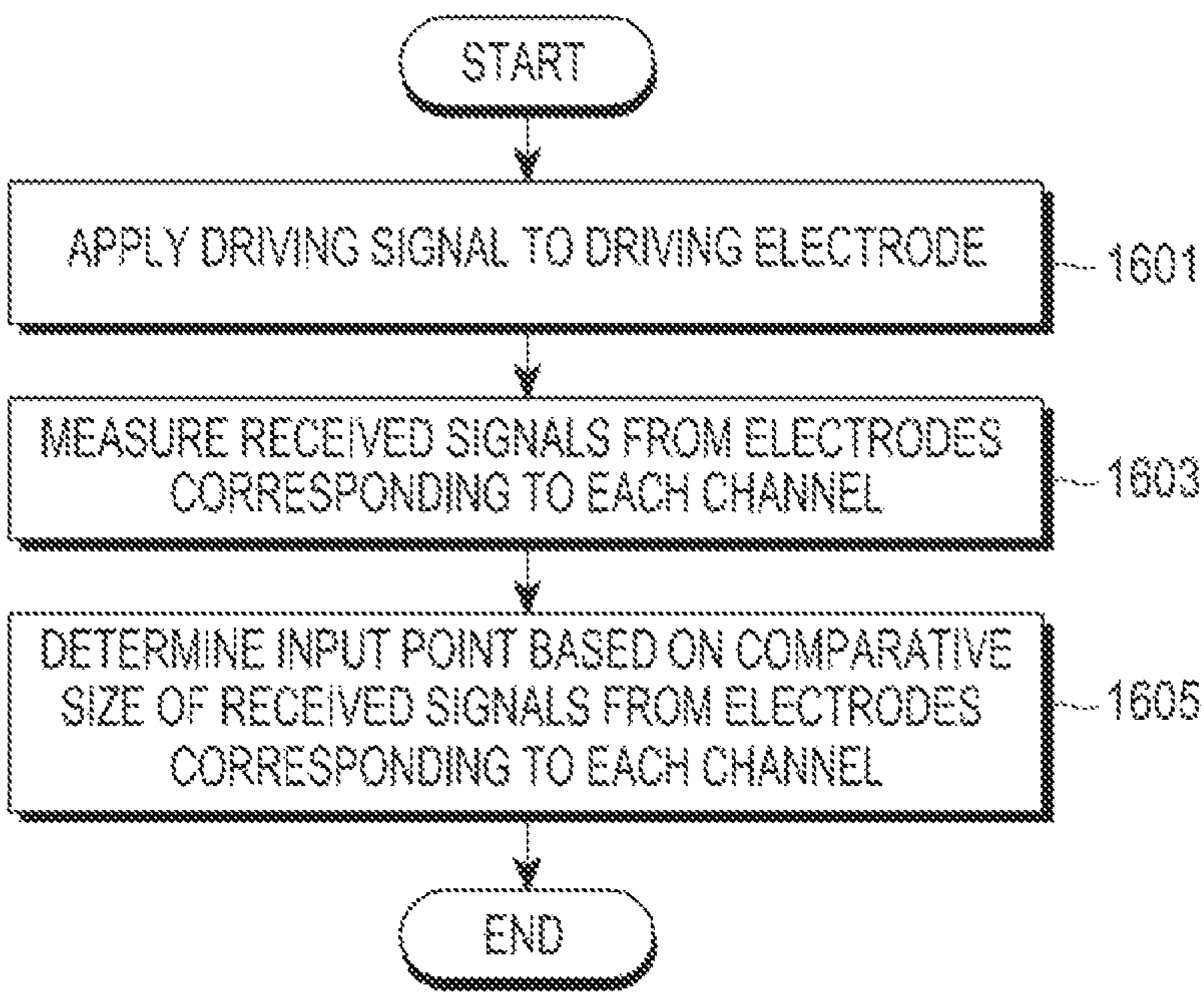

START
APPLY DRIVING SIGNAL TO DRIVING ELECTRODE
1601
MEASURE RECEIVED SIGNALS FROM ELECTRODES CORRESPONDING TO EACH CHANNEL
1603
DETERMINE INPUT POINT BASED ON COMPARATIVE SIZE OF RECEIVED SIGNALS FROM ELECTRODES CORRESPONDING TO EACH CHANNEL
1605
END

FIG.16

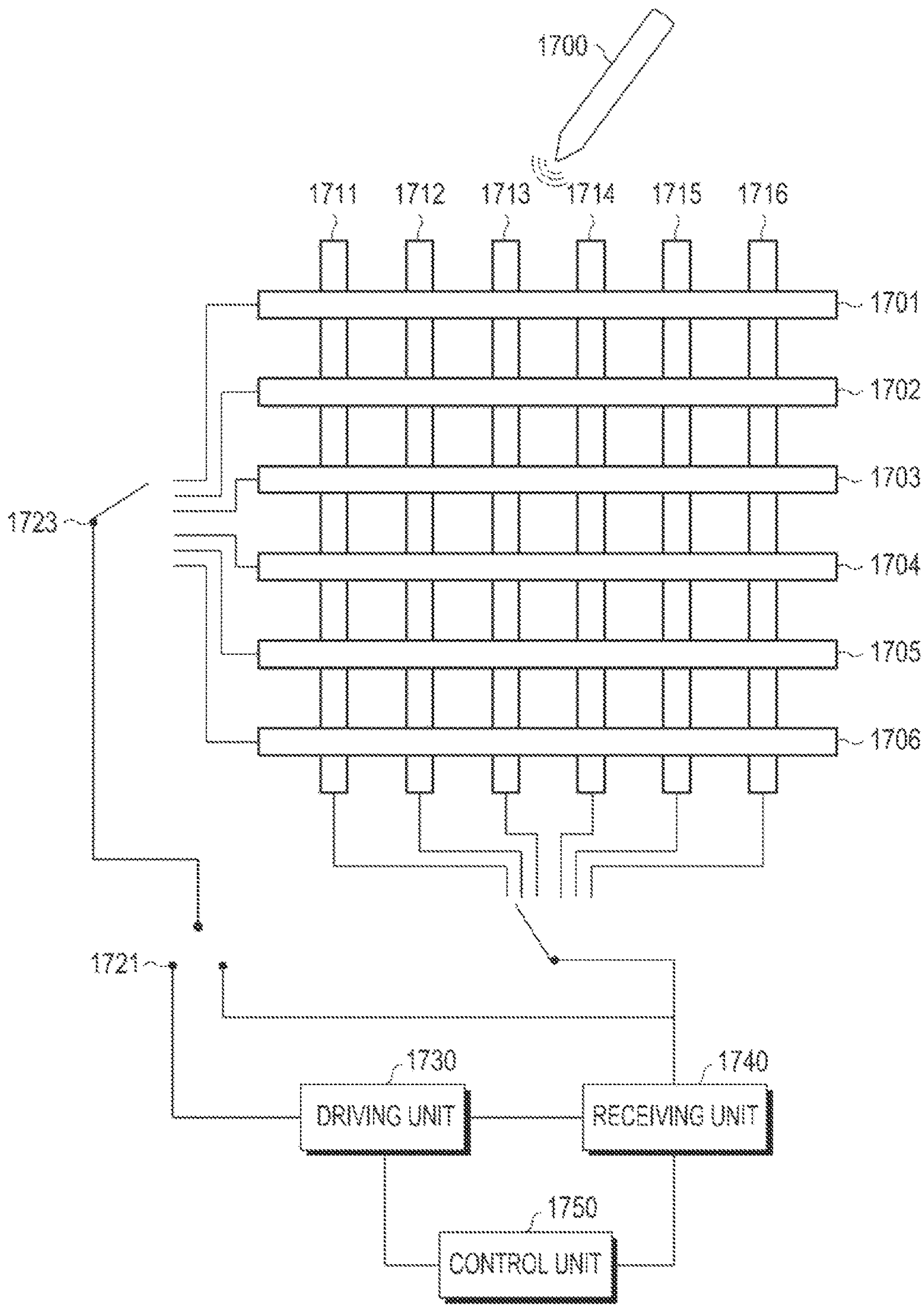

1700
1711
1712
1713
1714
1715
1716
1701
1702
1703
1704
1705
1706
1723
1721
1730
DRIVING UNIT
1740
RECEIVING UNIT
1750
CONTROL UNIT

FIG.17A

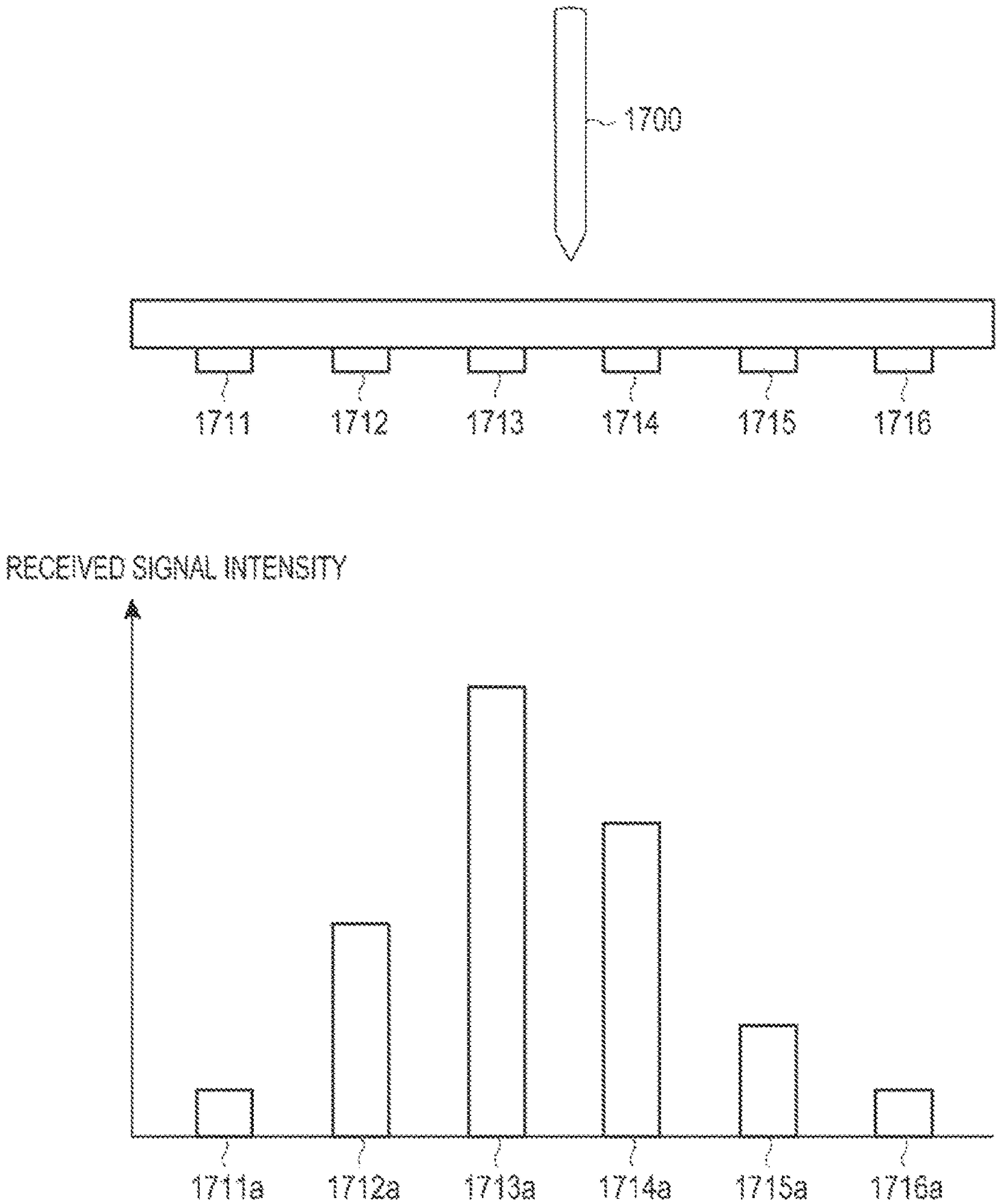

1700
1711
1712
1713
1714
1715
1716
RECEIVED SIGNAL INTENSITY
1711a
1712a
1713a
1714a
1715a
1716a

FIG.17B

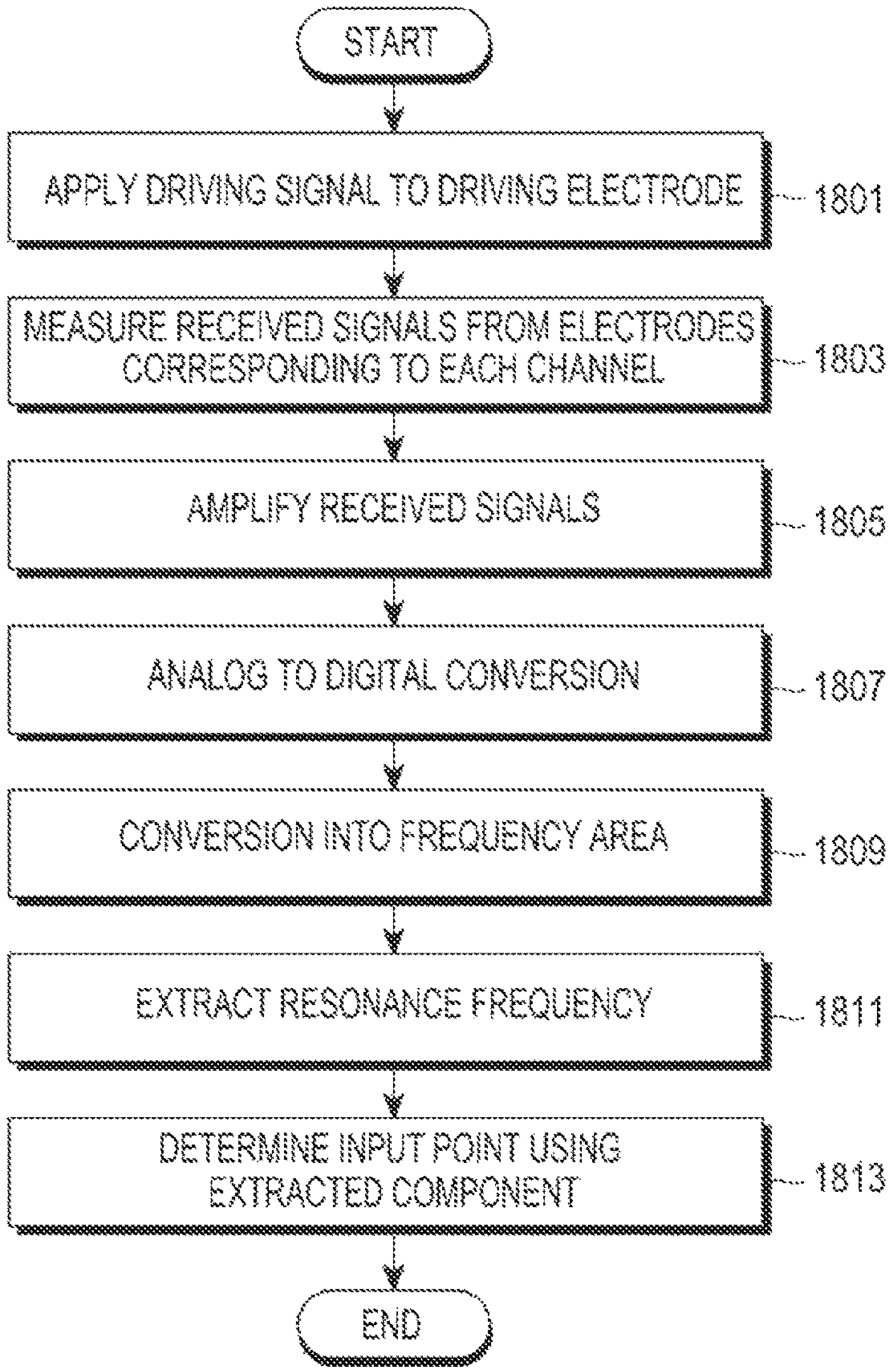

START
APPLY DRIVING SIGNAL TO DRIVING ELECTRODE
1801
MEASURE RECEIVED SIGNALS FROM ELECTRODES CORRESPONDING TO EACH CHANNEL
1803
AMPLIFY RECEIVED SIGNALS
1805
ANALOG TO DIGITAL CONVERSION
1807
CONVERSION INTO FREQUENCY AREA
1809
EXTRACT RESONANCE FREQUENCY
1811
DETERMINE INPUT POINT USING EXTRACTED COMPONENT
1813
END

FIG.18

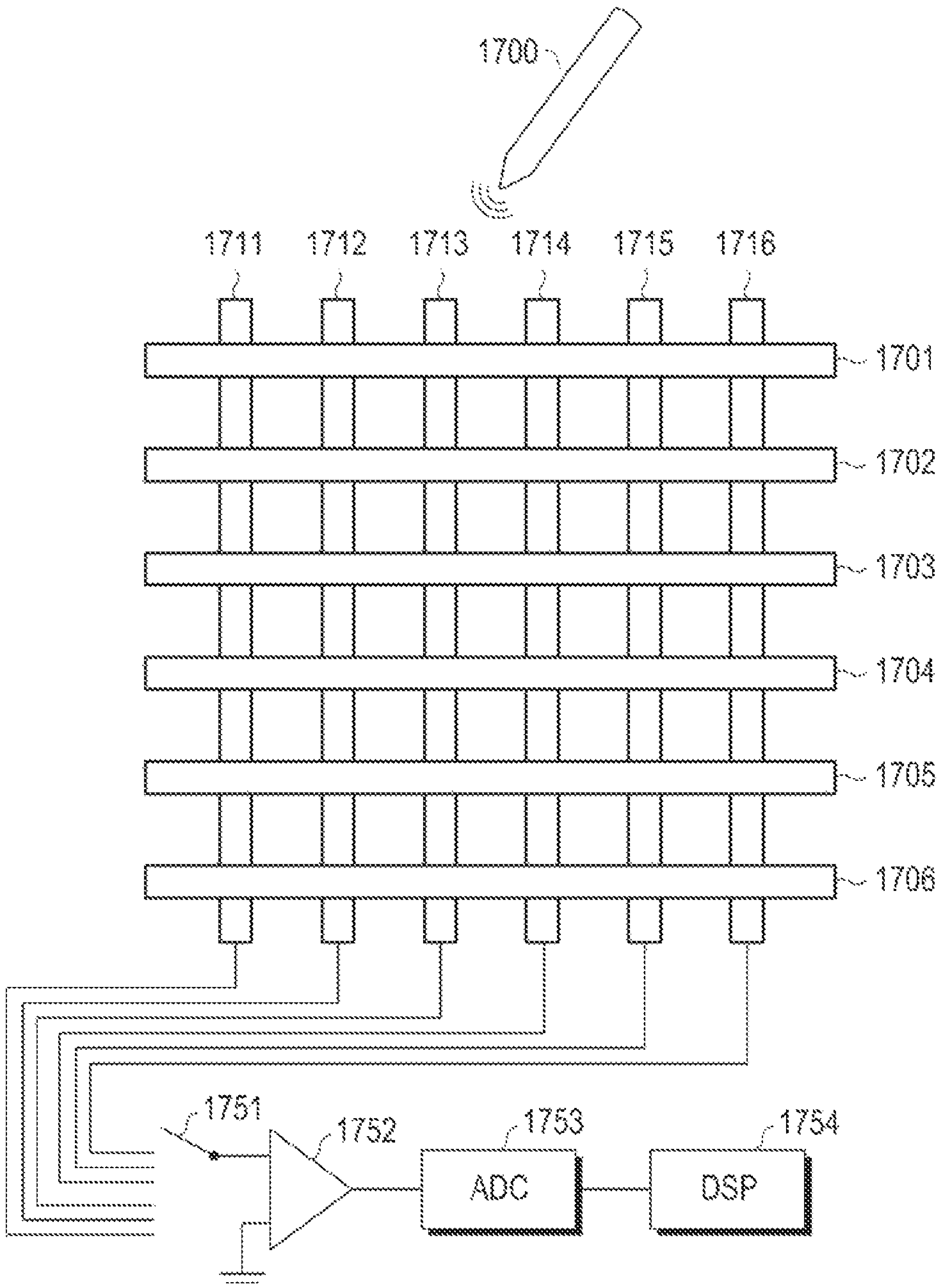

1700
1711
1712
1713
1714
1715
1716
1701
1702
1703
1704
1705
1706
1751
1752
1753
1754
ADC
DSP

FIG.19A

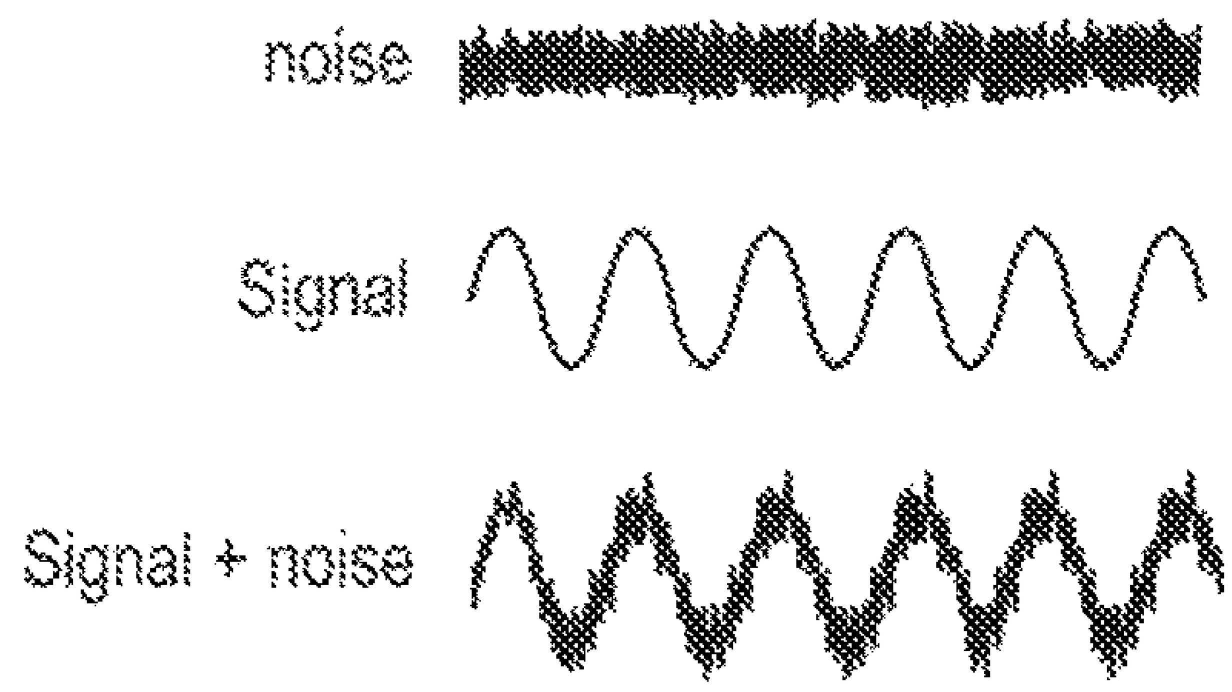


FIG.19B

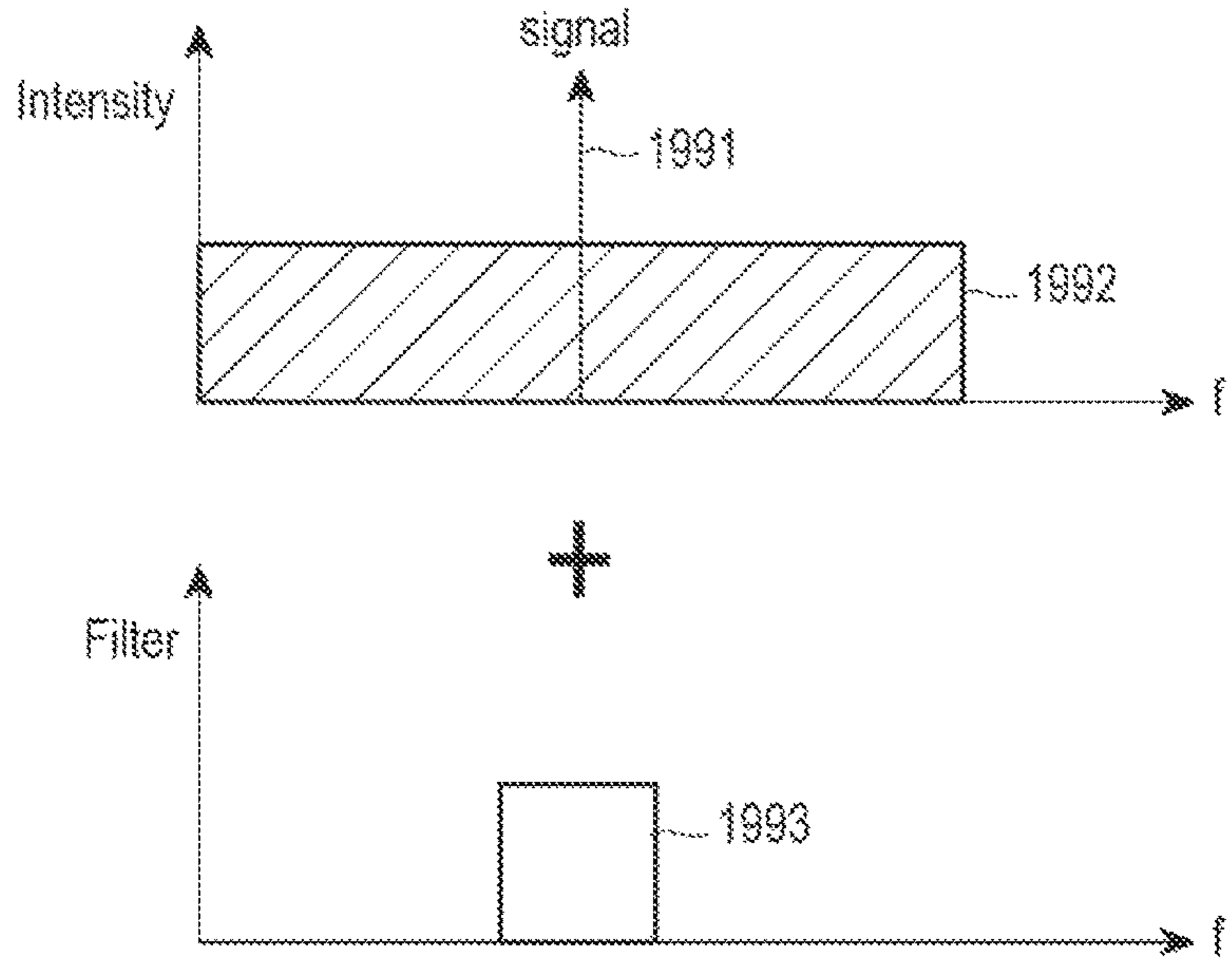


FIG.19C

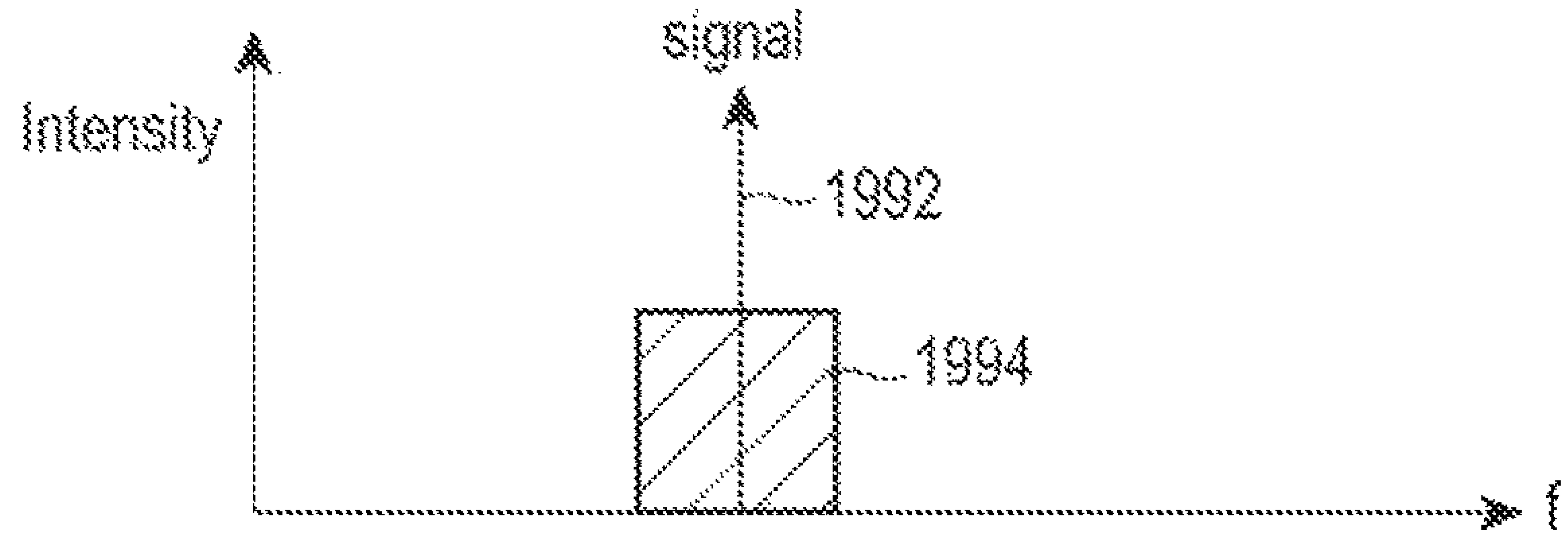


FIG.19D

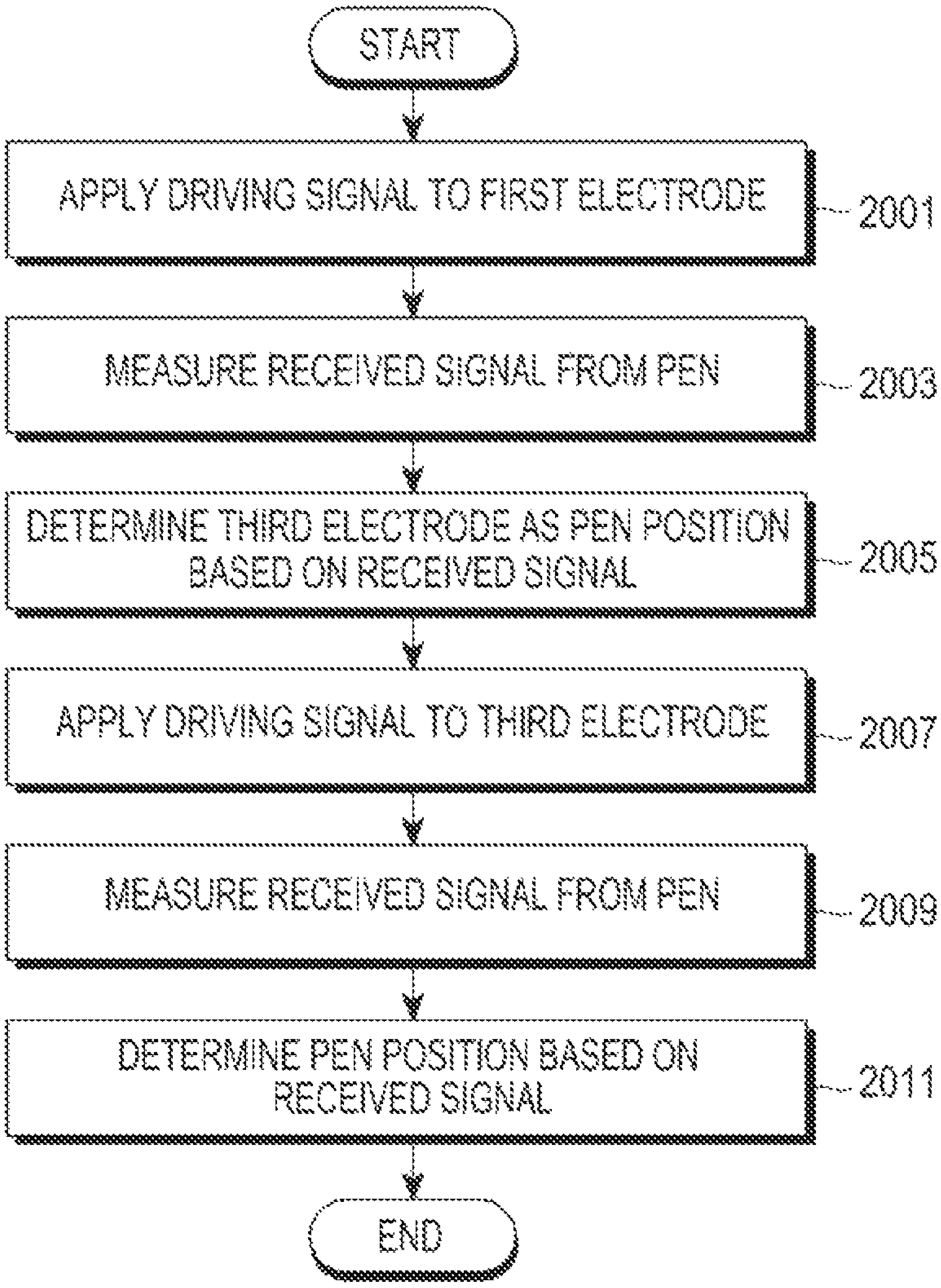

START
APPLY DRIVING SIGNAL TO FIRST ELECTRODE
2001
MEASURE RECEIVED SIGNAL FROM PEN
2003
DETERMINE THIRD ELECTRODE AS PEN POSITION BASED ON RECEIVED SIGNAL
2005
APPLY DRIVING SIGNAL TO THIRD ELECTRODE
2007
MEASURE RECEIVED SIGNAL FROM PEN
2009
DETERMINE PEN POSITION BASED ON RECEIVED SIGNAL
2011
END

FIG.20

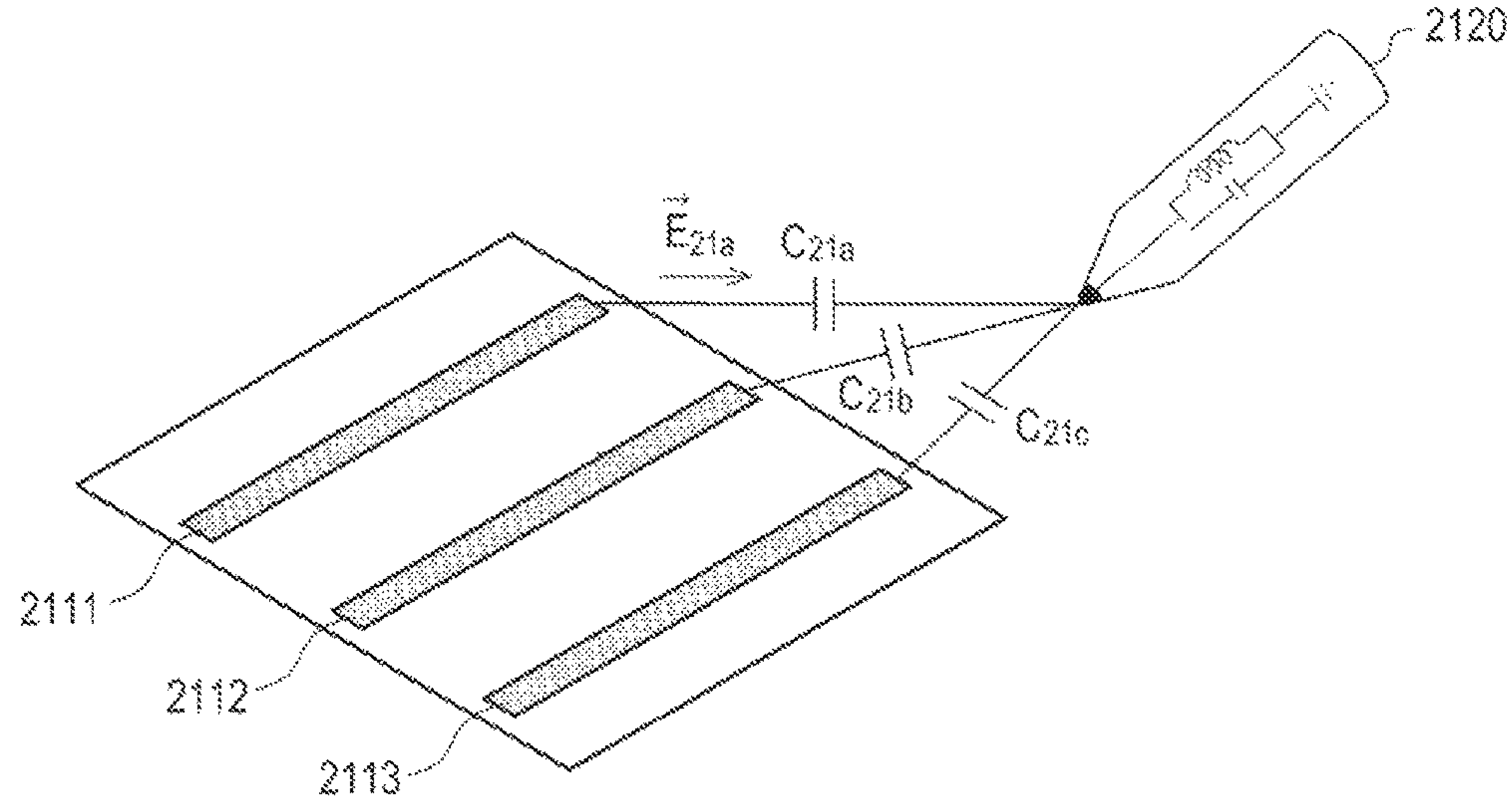


FIG.21A

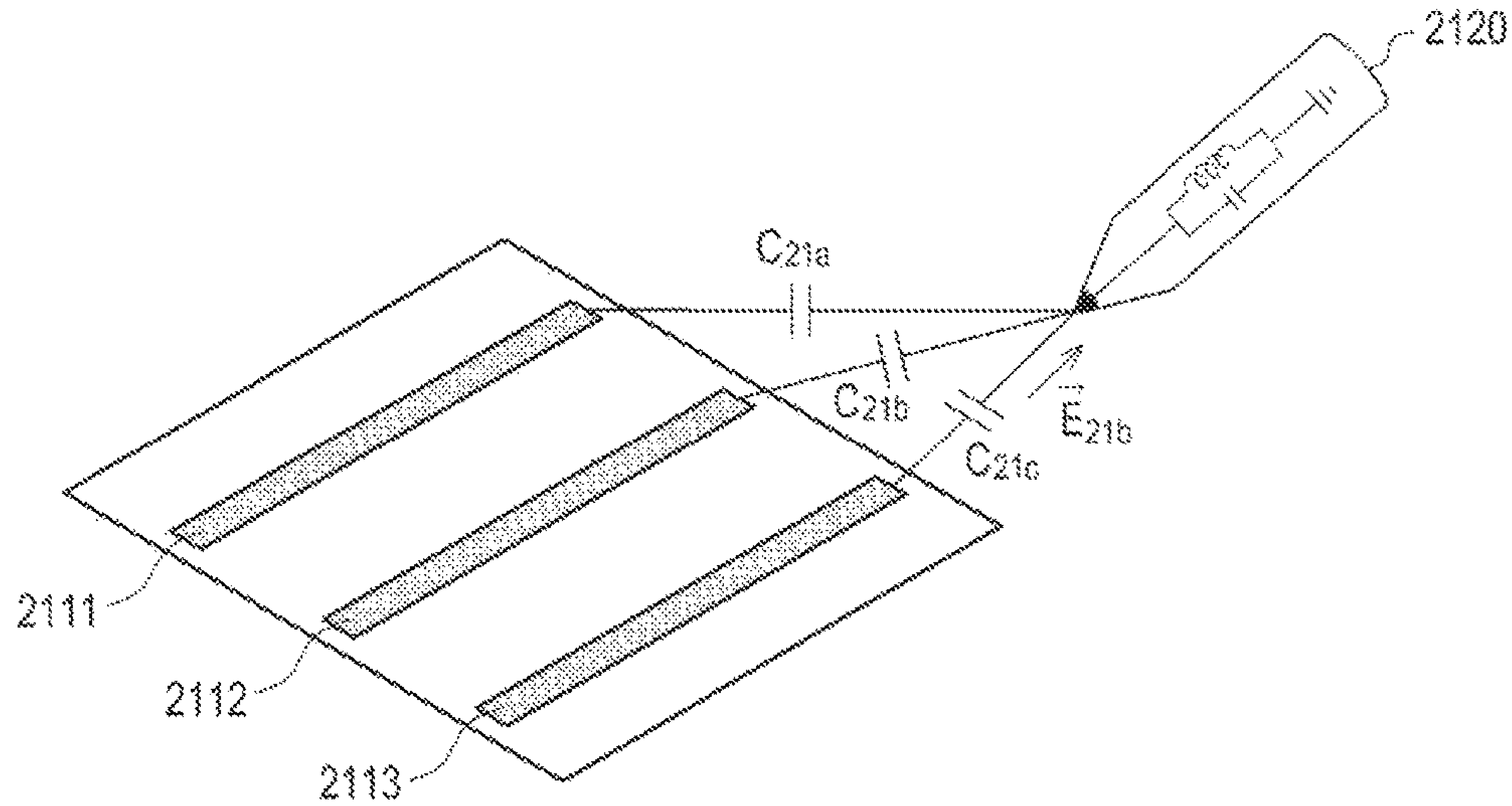


FIG.21B

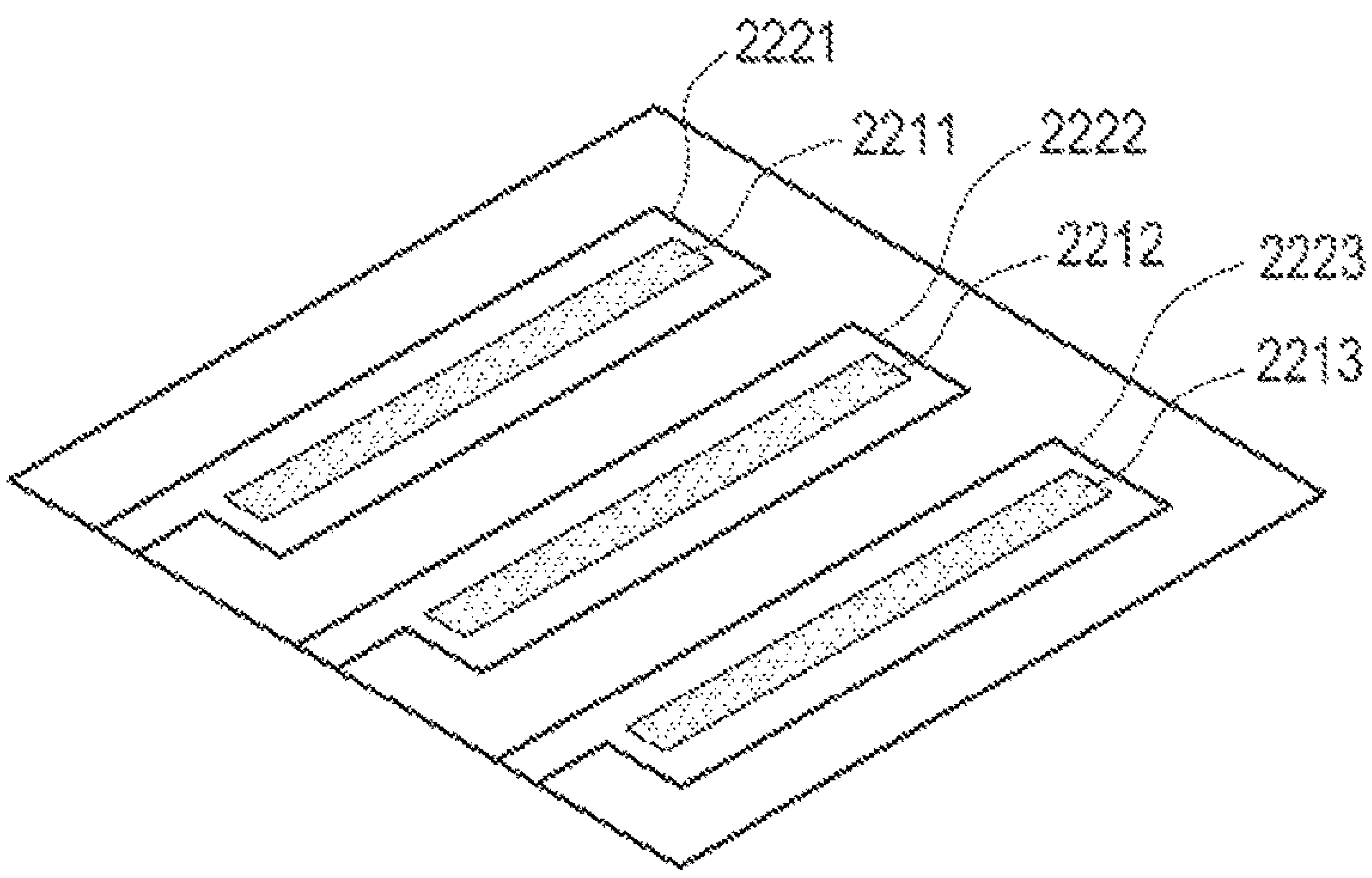


FIG.22A

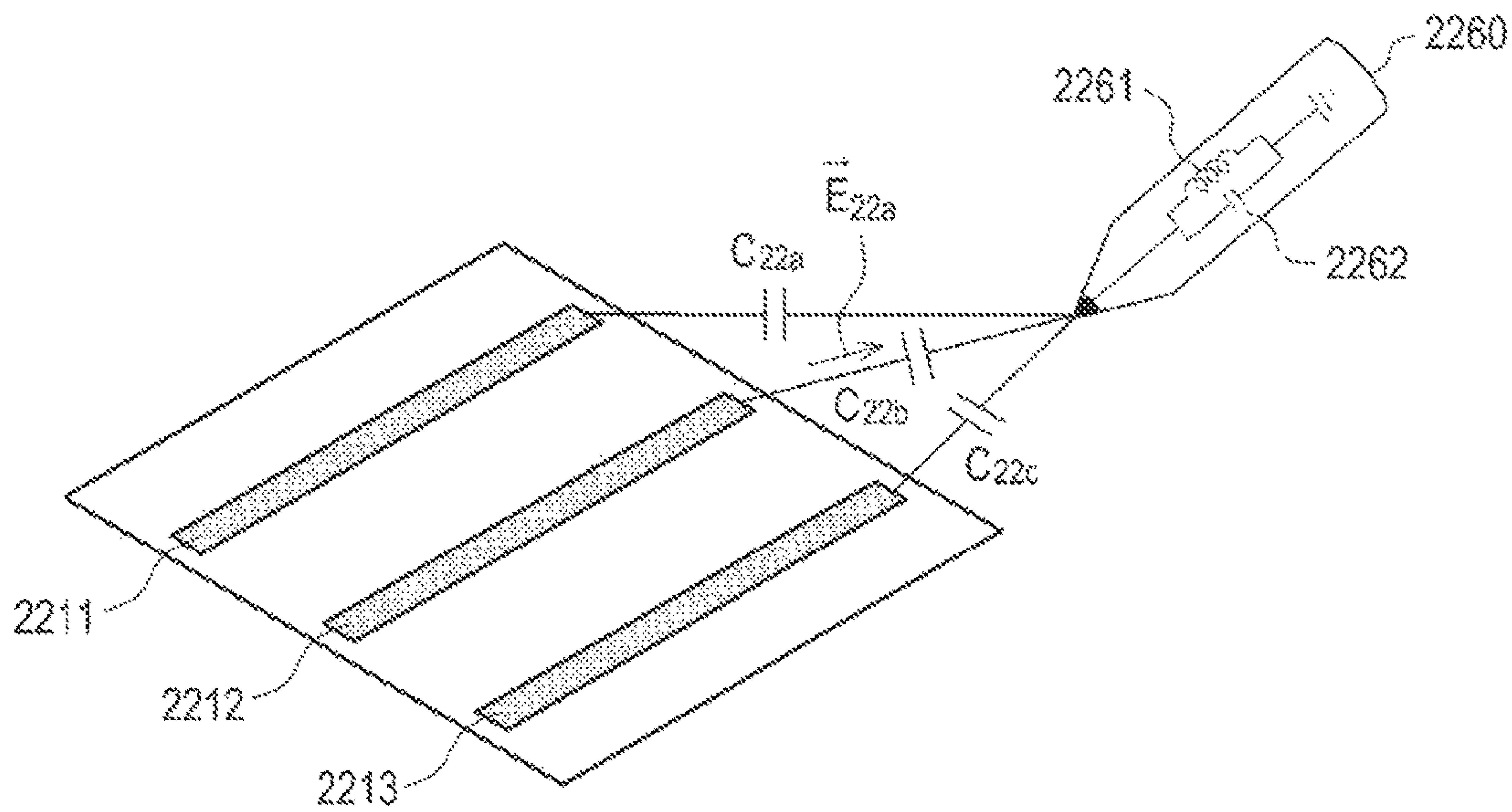


FIG.22B

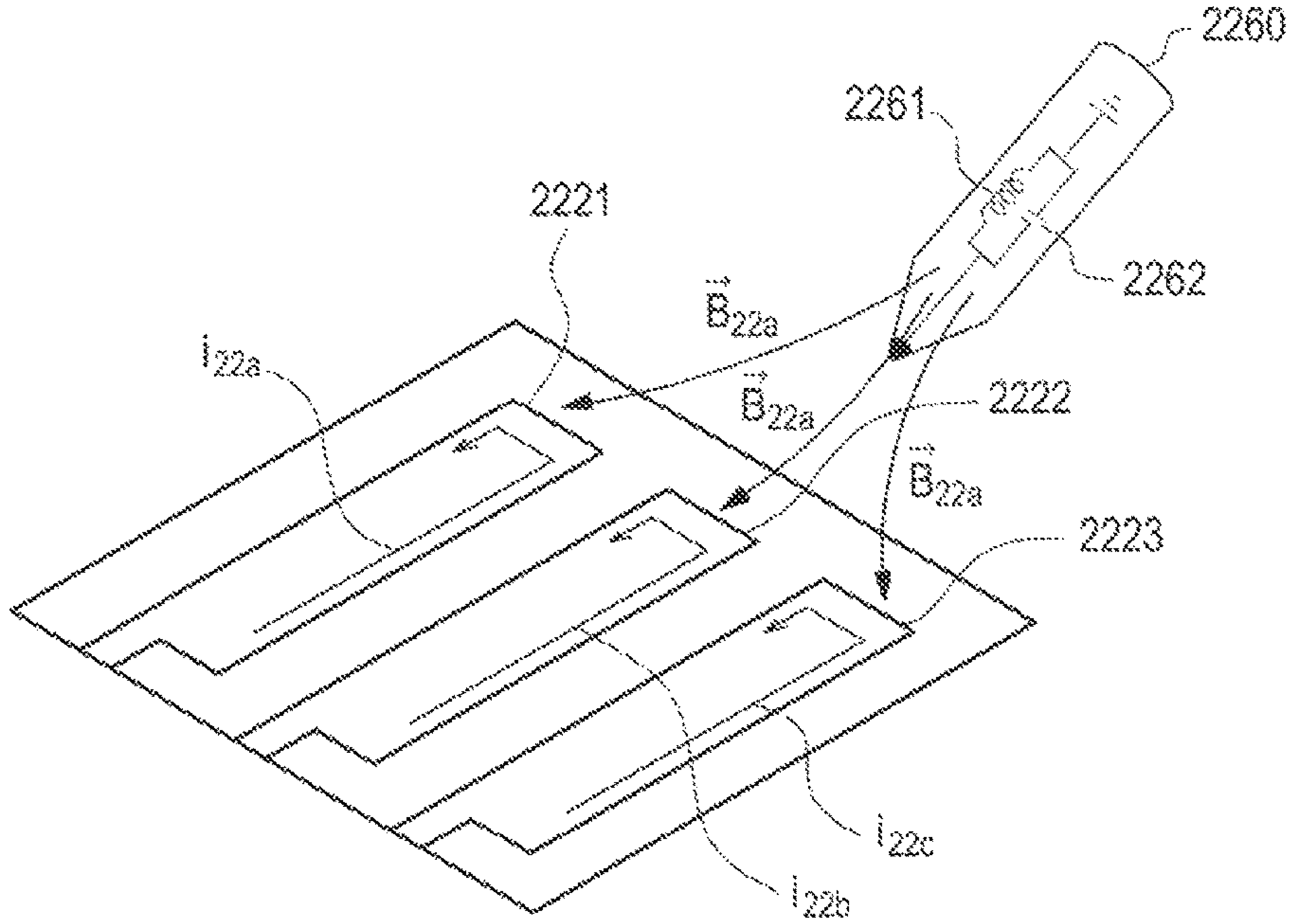

2260
2261
2262
2221
2222
2223
$\vec{B}_{22a}$
$\vec{B}_{22a}$
$\vec{B}_{22a}$
i_{22a}
i_{22b}
i_{22c}

FIG.22C

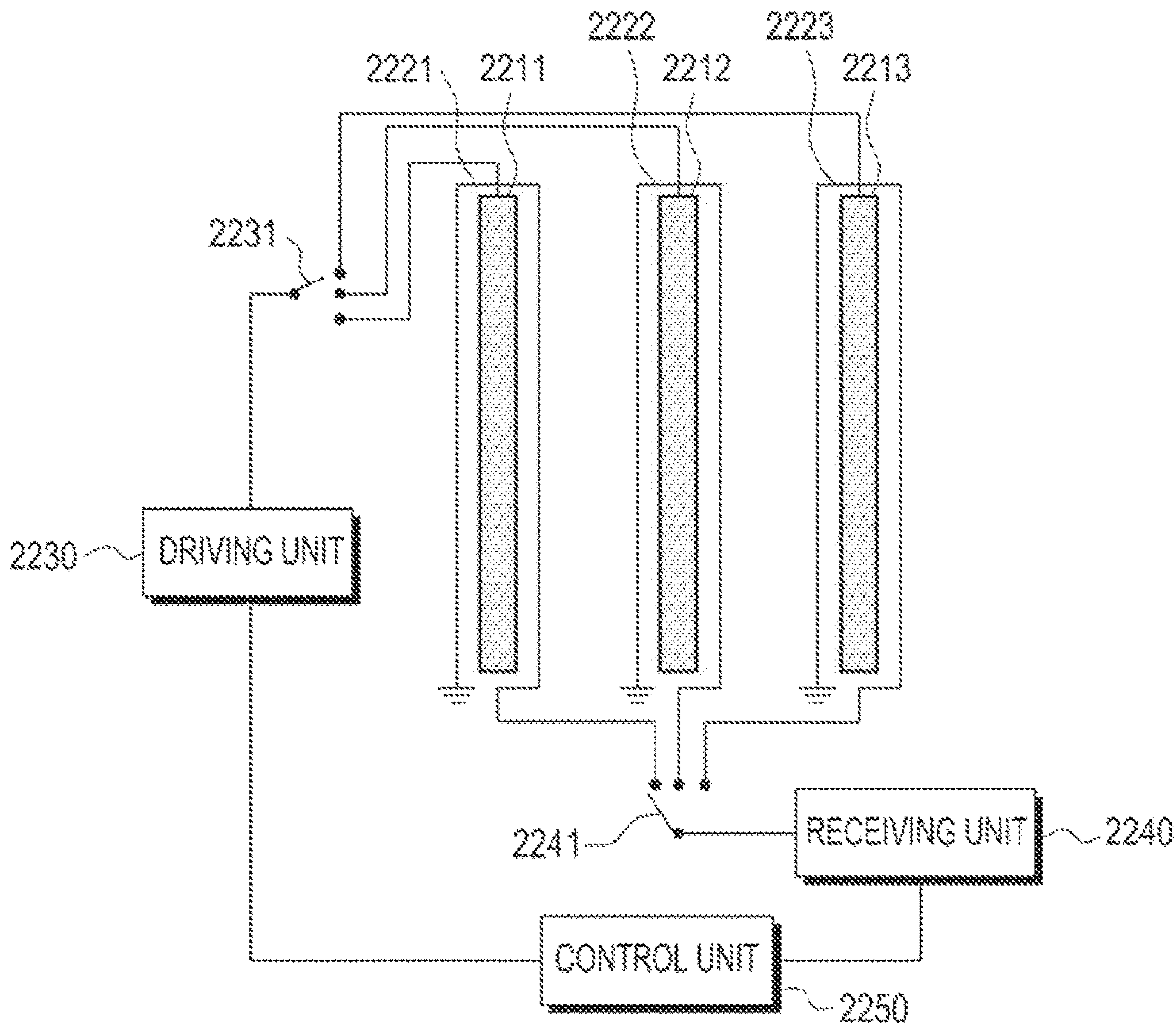

2222
2223
2221
2211
2212
2213
2231
2230
DRIVING UNIT
2241
RECEIVING UNIT
2240
CONTROL UNIT
2250

FIG.23

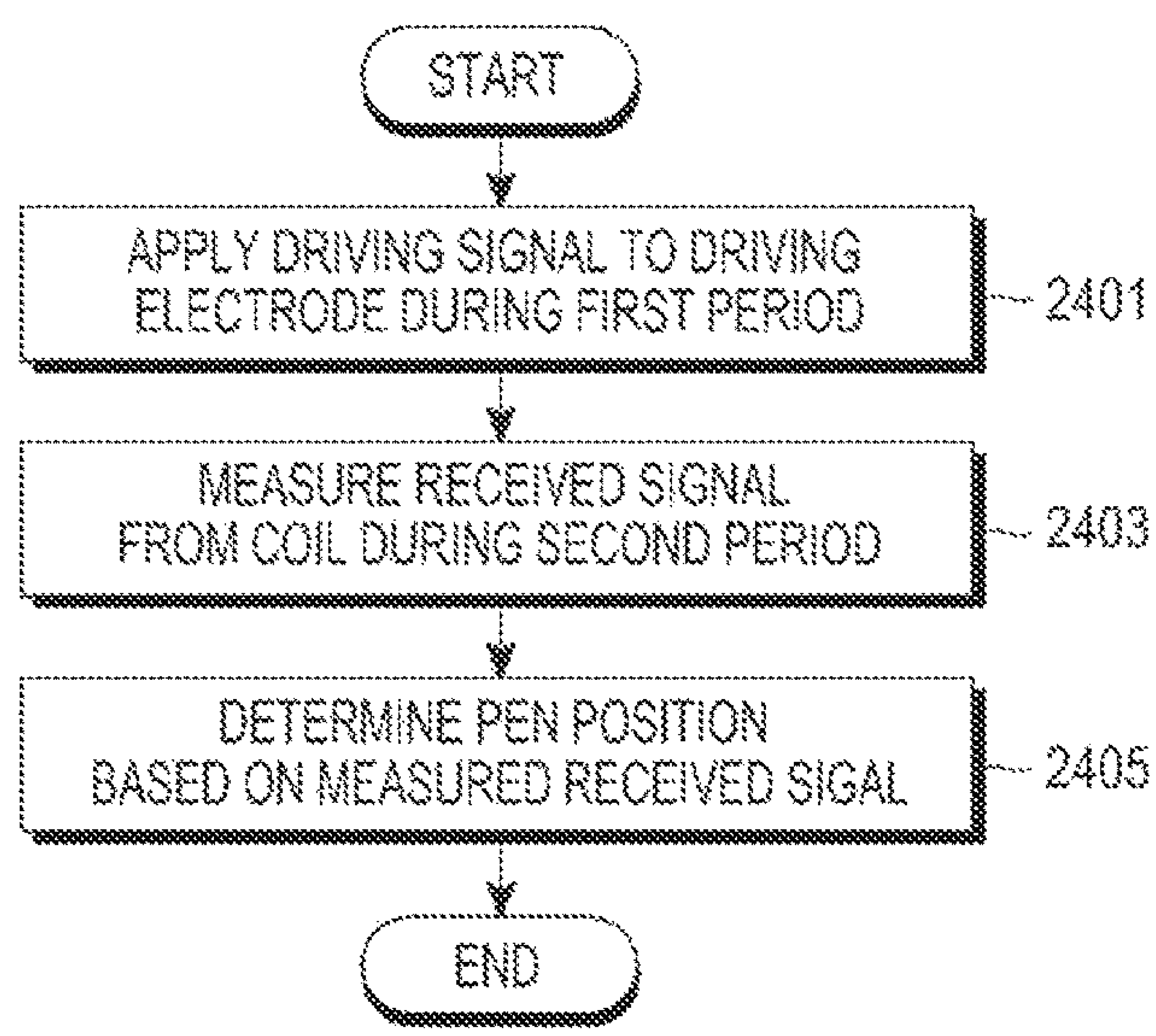

START
APPLY DRIVING SIGNAL TO DRIVING ELECTRODE DURING FIRST PERIOD
2401
MEASURE RECEIVED SIGNAL FROM COIL DURING SECOND PERIOD
2403
DETERMINE PEN POSITION BASED ON MEASURED RECEIVED SIGAL
2405
END

FIG.24

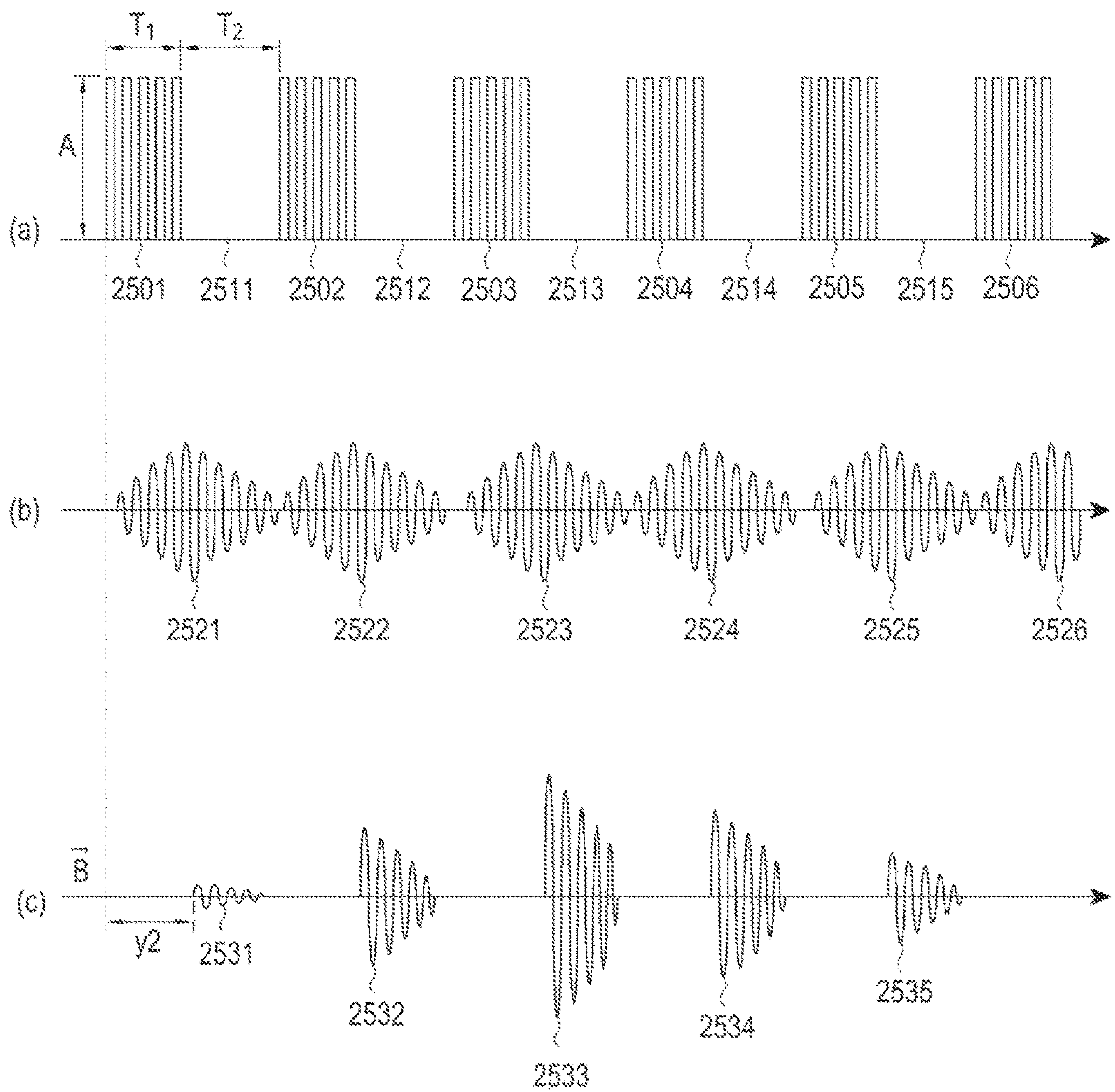

T1
T2
A
(a)
2501
2511
2502
2512
2503
2513
2504
2514
2505
2515
2506
(b)
2521
2522
2523
2524
2525
2526
B
(c)
y2
2531
2532
2533
2534
2535

FIG.25

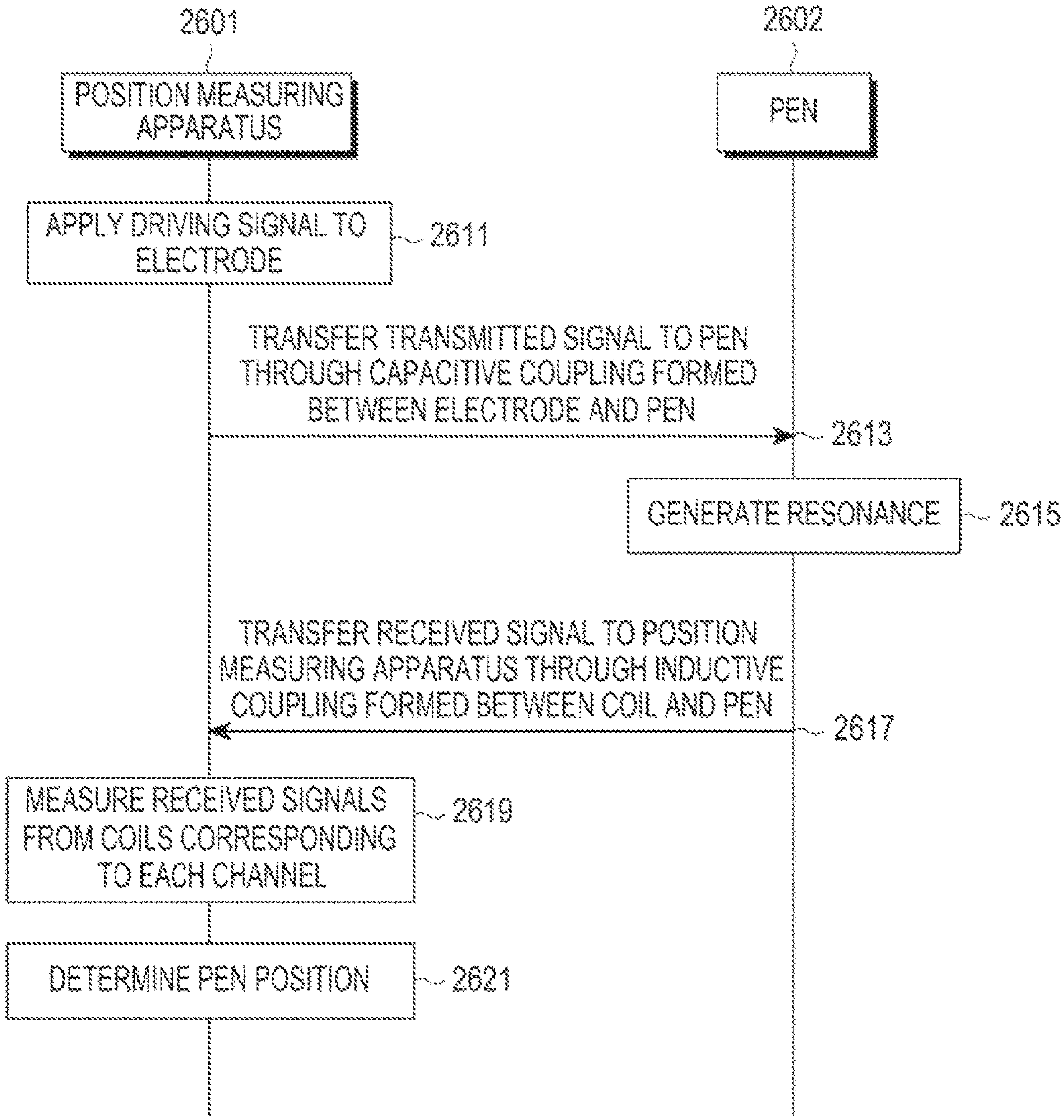

2601
POSITION MEASURING APPARATUS
2602
PEN
APPLY DRIVING SIGNAL TO ELECTRODE
2611
TRANSFER TRANSMITTED SIGNAL TO PEN THROUGH CAPACITIVE COUPLING FORMED BETWEEN ELECTRODE AND PEN
2613
GENERATE RESONANCE
2615
TRANSFER RECEIVED SIGNAL TO POSITION MEASURING APPARATUS THROUGH INDUCTIVE COUPLING FORMED BETWEEN COIL AND PEN
2617
MEASURE RECEIVED SIGNALS FROM COILS CORRESPONDING TO EACH CHANNEL
2619
DETERMINE PEN POSITION
2621

FIG.26

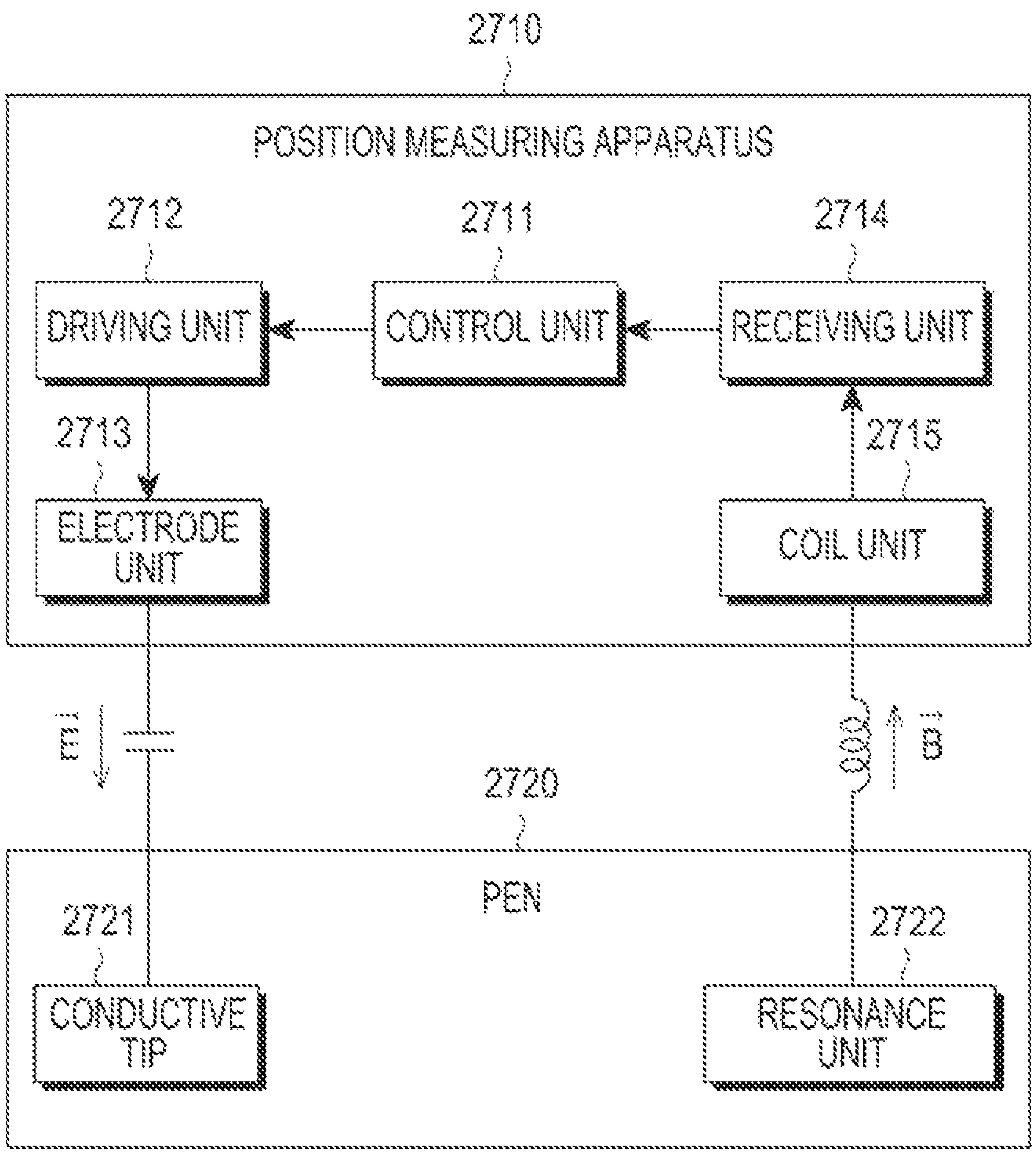

2710
POSITION MEASURING APPARATUS
2712
2711
2714
DRIVING UNIT
CONTROL UNIT
RECEIVING UNIT
2713
2715
ELECTRODE UNIT
COIL UNIT
E
B
2720
PEN
2721
2722
CONDUCTIVE TIP
RESONANCE UNIT

FIG.27

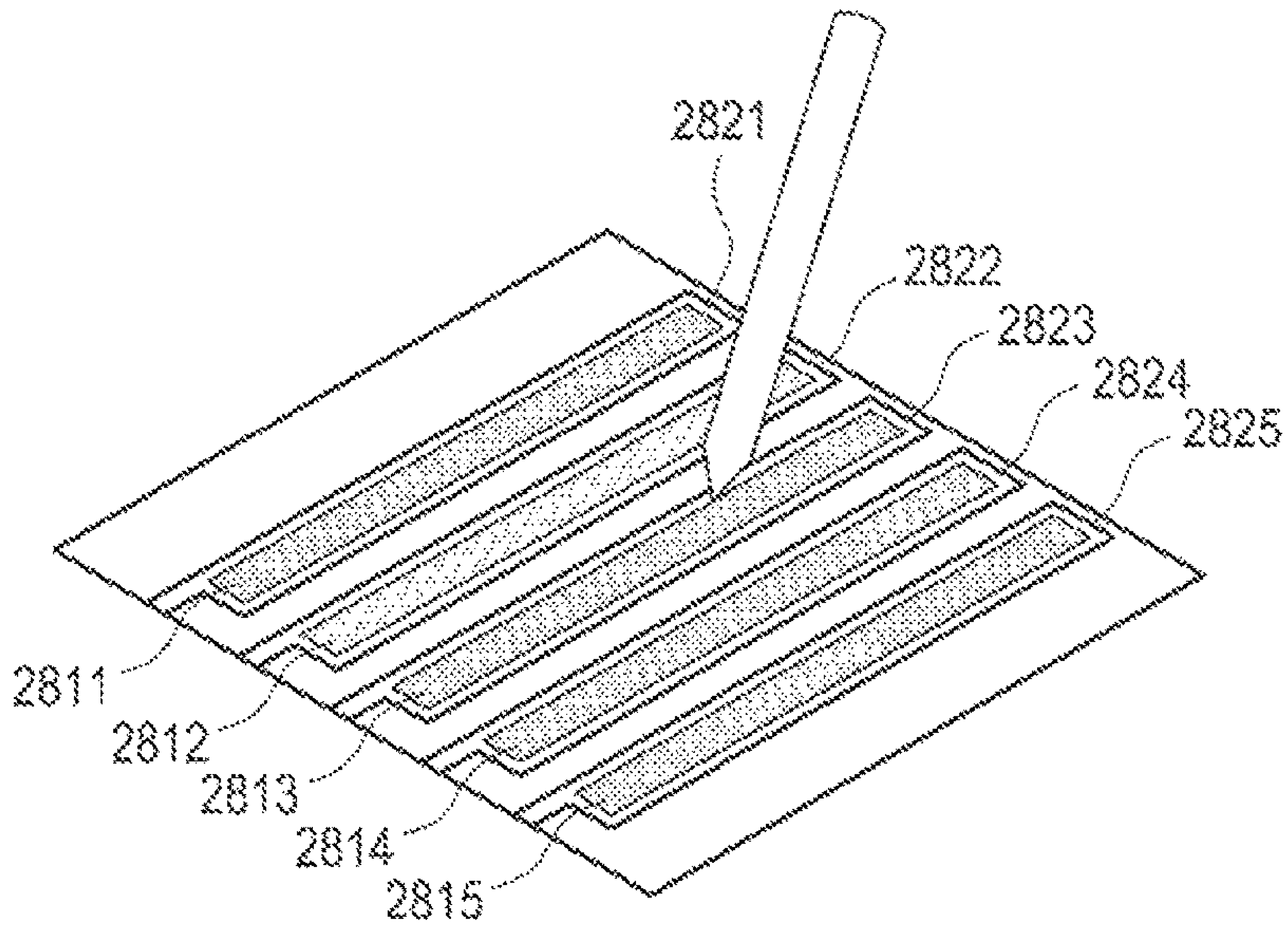
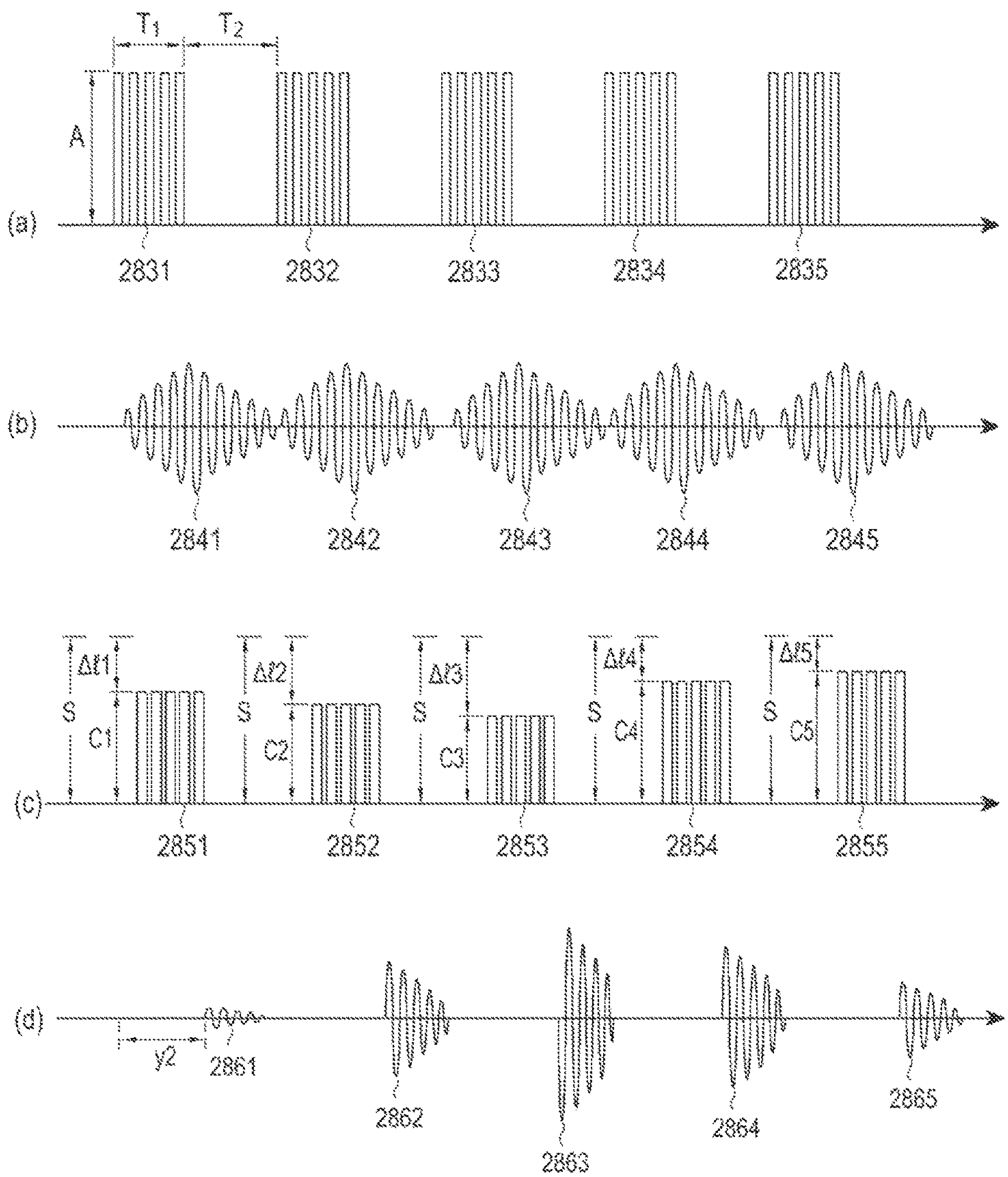


FIG.28A



T1
T2
A
(a)
2831
2832
2833
2834
2835
(b)
2841
2842
2843
2844
2845
Δℓ1
Δℓ2
Δℓ3
Δℓ4
Δℓ5
S
C1
C2
C3
C4
C5
(c)
2851
2852
2853
2854
2855
(d)
y2
2861
2862
2863
2864
2865

FIG.28B

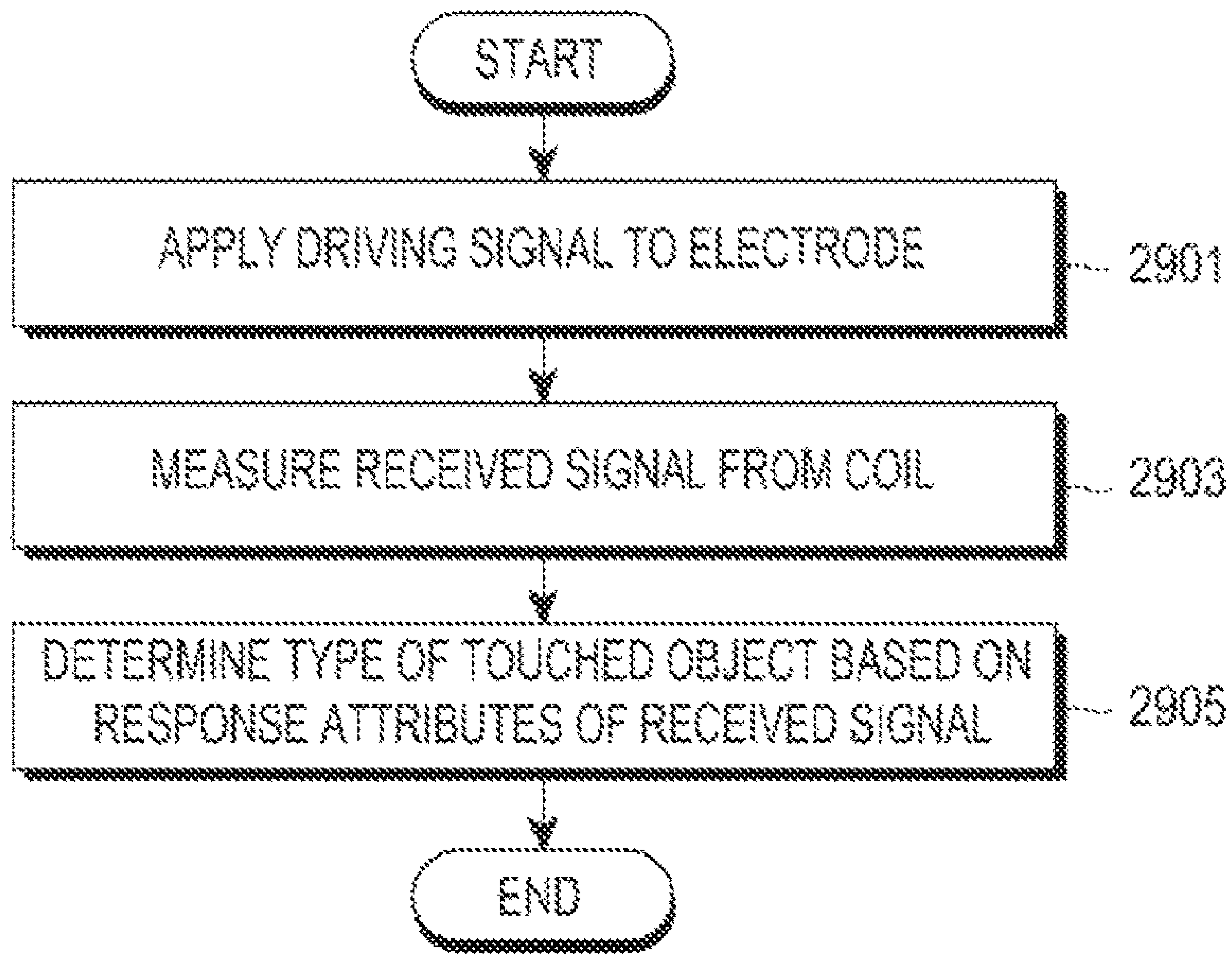

START
APPLY DRIVING SIGNAL TO ELECTRODE
2901
MEASURE RECEIVED SIGNAL FROM COIL
2903
DETERMINE TYPE OF TOUCHED OBJECT BASED ON RESPONSE ATTRIBUTES OF RECEIVED SIGNAL
2905
END

FIG.29

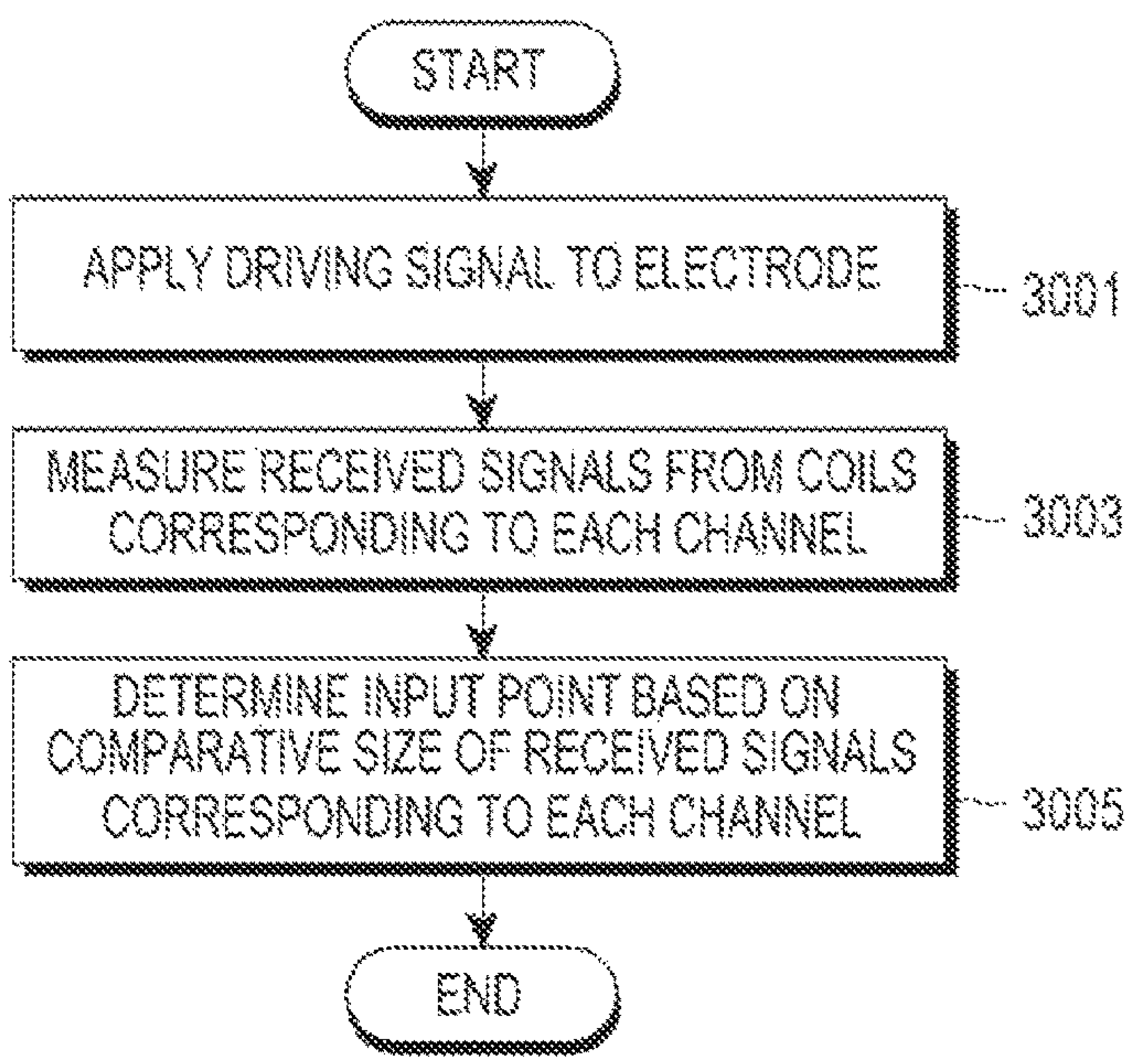

START
APPLY DRIVING SIGNAL TO ELECTRODE
3001
MEASURE RECEIVED SIGNALS FROM COILS CORRESPONDING TO EACH CHANNEL
3003
DETERMINE INPUT POINT BASED ON COMPARATIVE SIZE OF RECEIVED SIGNALS CORRESPONDING TO EACH CHANNEL
3005
END

FIG.30

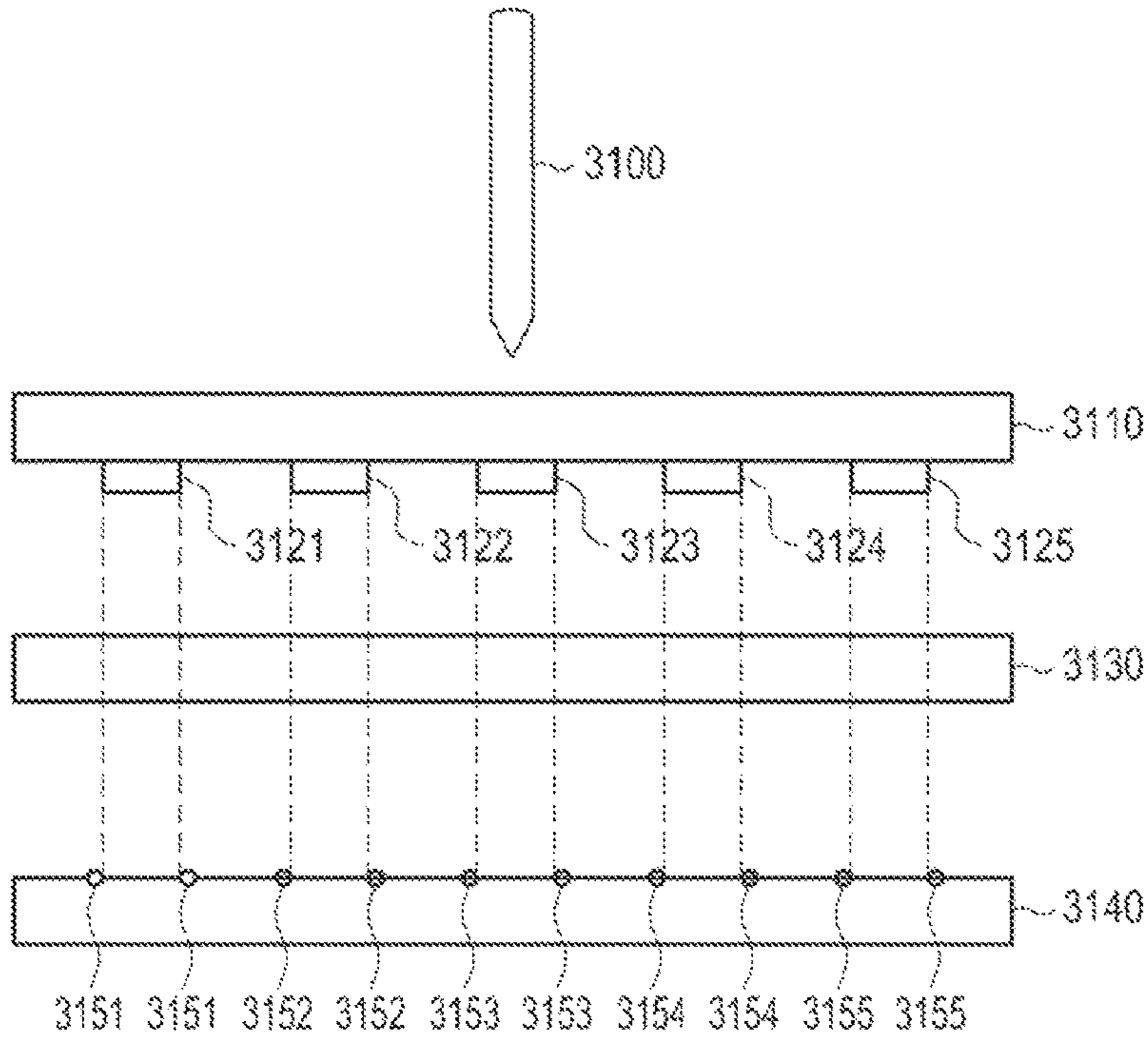


FIG.31A

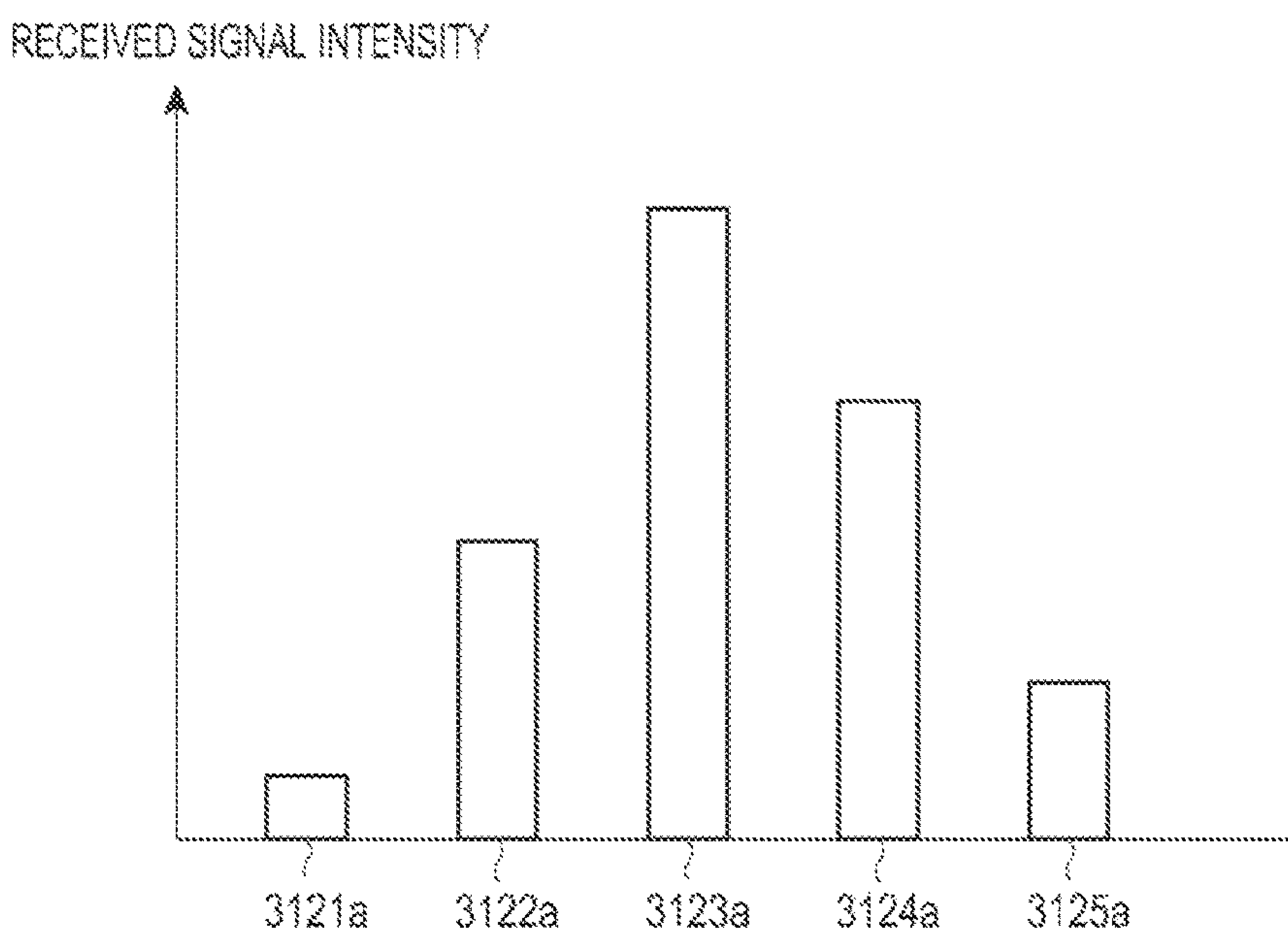


FIG.31B

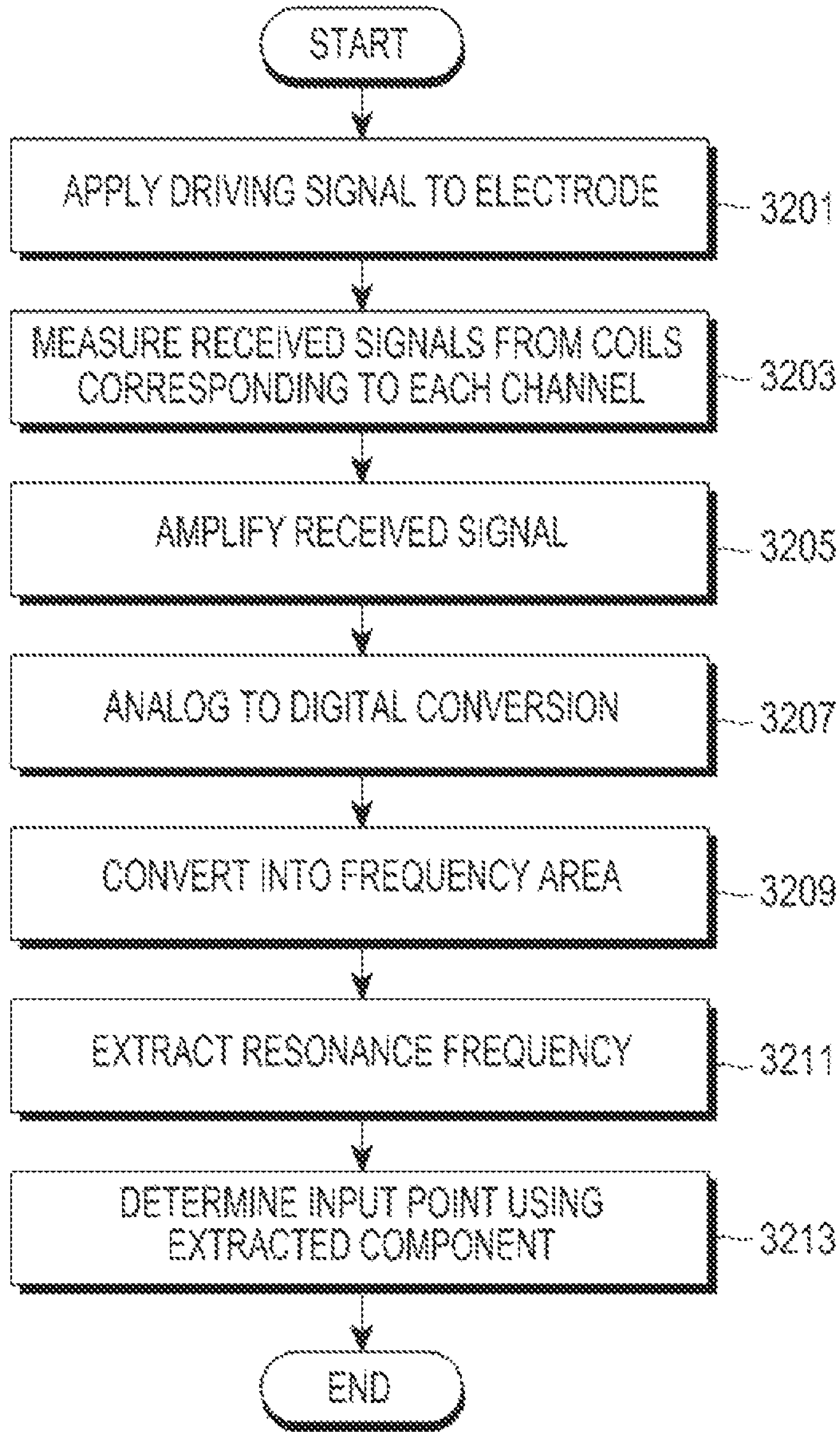

START
APPLY DRIVING SIGNAL TO ELECTRODE
3201
MEASURE RECEIVED SIGNALS FROM COILS CORRESPONDING TO EACH CHANNEL
3203
AMPLIFY RECEIVED SIGNAL
3205
ANALOG TO DIGITAL CONVERSION
3207
CONVERT INTO FREQUENCY AREA
3209
EXTRACT RESONANCE FREQUENCY
3211
DETERMINE INPUT POINT USING EXTRACTED COMPONENT
3213
END

FIG.32

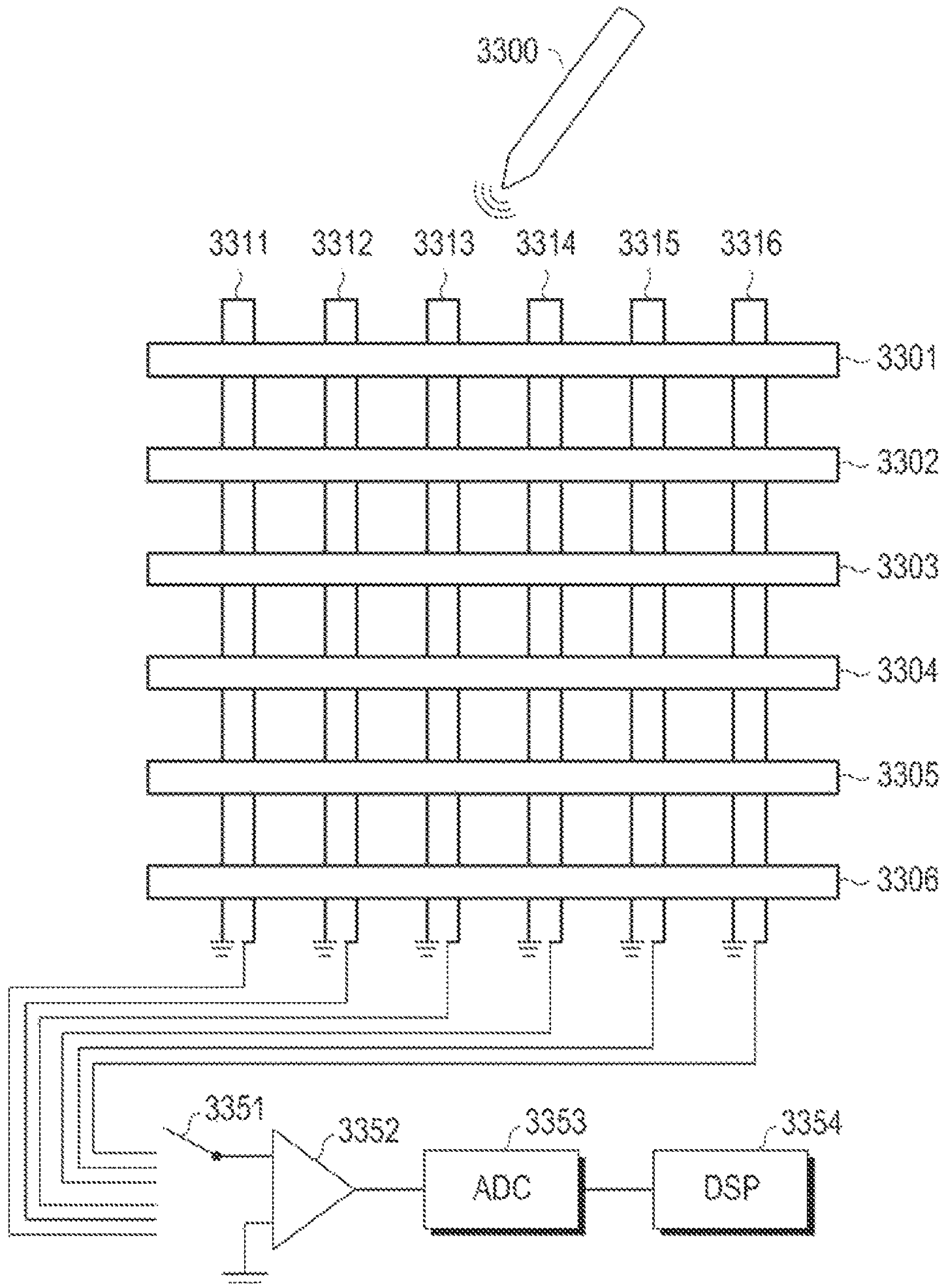

3300
3311
3312
3313
3314
3315
3316
3301
3302
3303
3304
3305
3306
3351
3352
3353
3354
ADC
DSP

FIG.33

POSITION MEASURING APPARATUS, PEN AND POSITION MEASURING METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation application of a prior application Ser. No. 13/857,713, filed on Apr. 5, 2013, which claimed the benefit under 35 U.S.C § 119(a) of a Korean patent application filed on May 11, 2012 in the Korean Intellectual Property Office and assigned Serial number 10-2012-0050371, the entire disclosures of each of which are hereby incorporated by reference.

TECHNICAL FIELD

The present disclosure relates to a position measuring apparatus, a pen, and a position measuring method.

BACKGROUND

Currently, a smart phone or a tablet PC is actively disseminated, and a technology for a contact position measurement apparatus embedded in the smart phone or the tablet PC is also actively developed. The smart phone or the tablet PC mainly includes a touch screen, and a user designates a particular coordinate of the touch screen by using a finger or a stylus pen. The user can input a particular signal in the smart phone by designating the particular coordinate of the touch screen.

The touch screen may operate based on an electricity type, an infrared light type, an ultrasonic wave type and the like, and an example of the electricity operation type may include an R type touch screen (resistive touch screen) or a C type touch screen (capacitive touch screen). Among touch screens, the R type touch screen capable of simultaneously recognizing a user's finger and a stylus pen has been widely used in the related art, but the R type touch screen has a problem in that there is a reflection due to an air space between ITO layers. More specifically, transmissivity of light penetrating a display is reduced due to the air space between the ITO layers, and an external light reflection is increased.

Accordingly, currently, the C type touch screen is widely applied. The C type touch screen operates in a mode of detecting a difference in capacitance of a transparent electrode generated by a contact of an object. However, since the touch screen has difficulty in physically distinguishing between a hand and a pen, an unintended operation error by a contact of the hand may occur when the pen is used.

The related art to solve the above mentioned problem includes a method using software for distinguishing between the hand and the pen according to a contact area, and a method including a separate position measurement apparatus such as an Electro Magnetic Resonance (EMR) technique as well as the C type touch screen. However, the method of using software cannot completely resolve the unintended operation error generated due to the contact of the hand, and the method including the separate measurement apparatus increases volume, weight, and costs by requiring additional components.

Therefore, it is required to develop a technology capable of performing a determination without the operation error when an object, such as the stylus pen, is used without using a separate position measurement apparatus.

SUMMARY

The present disclosure may provide a position measuring apparatus including only an electrode, a pen, and a position measuring method.

According to an aspect of the present disclosure, a position measuring apparatus that measures a position of a pen may include one or more electrodes, and a control unit that controls to transmit an electric field transmission signal generated from one or more electrodes to the pen, and receives an electric field reception signal corresponding to the electric field transmission signal.

According to an aspect of the present disclosure, a pen that displays a position on a position measuring apparatus may include a conductive tip that receives an electric field transmission signal generated from one or more electrodes of the position measuring apparatus, and a resonance circuit that generates an electric field reception signal corresponding to the electric field transmission signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features, and advantages of the present disclosure will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIGS. **1**A to **1**C illustrate configurations of a comparison embodiment for comparing with the present disclosure;

FIGS. **2**A to **2**C illustrate panels of a position measuring apparatus that measures positions of a finger and a pen by the comparison embodiment for comparing with the present disclosure;

FIG. **3** illustrates a panel of a position measuring apparatus capable of determining a position of a pen according to various embodiments of the present disclosure;

FIGS. **4**A and **4**B illustrate plan views of an electrode arrangement of a position measuring apparatus according to various embodiments of the present disclosure;

FIGS. **5**A to **5**D illustrate conceptual diagrams of a pen position measurement of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. **6** illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. **7** illustrates waveforms of a signal generated or measured by various embodiments of the present disclosure;

FIG. **8** illustrates a flowchart of a pen position measuring method according to various embodiments of the present disclosure;

FIG. **9** illustrates a block diagram of a position measuring apparatus and a pen according to various embodiments of the present disclosure;

FIG. **10**A is a conceptual diagram of a pen according to various embodiments of the present disclosure;

FIG. **10**B illustrates a circuit configuration of the pen in FIG. **10**A according to various embodiments of the present disclosure;

FIG. **10**C is a cross-sectional view of a coordinate display apparatus according to an embodiment of the present disclosure;

FIG. **10**D illustrates a circuit diagram of the pen in FIG. **10**A according to various embodiments of the present disclosure;

FIG. **10**E is a conceptual diagram of a pen according to various embodiments of the present disclosure;

FIG. **10**F is a cross-sectional view of a pen according to an embodiment of the present disclosure;

FIG. 11A illustrates a conceptual diagram of a panel of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 11B illustrates a transmitted signal and a received signal of a case in which a finger touches;

FIG. 12A illustrates a conceptual diagram of a case in which a pen according to various embodiments of the present disclosure touches a panel;

FIG. 12B illustrates a transmitted signal and a received signal of a case in which a pen touches;

FIGS. 13A and 13B illustrate a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 14 illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 15 is a block diagram for describing a method of measuring a resonance frequency change due to a pen pressure or switch on and off states according to an embodiment of the present disclosure;

FIG. 16 illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 17A illustrates a conceptual diagram of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 17B illustrates a graph of received signals from electrodes corresponding to each channel according to various embodiments of the present disclosure;

FIG. 18 illustrates a flowchart of a noise eliminating method of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 19A illustrates a conceptual diagram for measuring a position of a pen according to various embodiments of the present disclosure;

FIG. 19B illustrates a signal waveform according to various embodiments of the present disclosure;

FIGS. 19C and 19D illustrate a noise elimination process according to various embodiments of the present disclosure;

FIG. 20 illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure;

FIGS. 21A and 21B illustrate a capacitive coupling forming according to various embodiments of the present disclosure;

FIGS. 22A to 22C illustrate a conceptual diagram of a position measuring apparatus that measures a position of a pen according to various embodiments of the present disclosure;

FIG. 23 illustrates a configuration diagram of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 24 illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 25 illustrates signals according to various embodiments of the present disclosure;

FIG. 26 illustrates a flowchart of a pen position measuring method according to various embodiments of the present disclosure;

FIG. 27 illustrates a block diagram of a position measuring apparatus and a pen according to various embodiments of the present disclosure;

FIG. 28A illustrates a conceptual diagram of a case in which a pen according to various embodiments of the present disclosure touches a panel;

FIG. 28B illustrates waveforms of signals generated or measured by various embodiments of the present disclosure;

FIG. 29 illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 30 illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 31A illustrates a conceptual diagram of a position measuring apparatus according to various embodiments of the present disclosure;

FIG. 31B illustrates a graph of received signals from electrodes corresponding to each channel according to various embodiments of the present disclosure;

FIG. 32 illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure; and

FIG. 33 illustrates a conceptual diagram of a position measuring apparatus according to various embodiments of the present disclosure.

DETAILED DESCRIPTION

Hereinafter, an embodiment of the present disclosure will be described in more detail with reference to the accompanying drawings. It should be noted that the same components of the drawings are designated by the same reference numeral anywhere. In the following description of the present disclosure, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present disclosure rather unclear.

FIG. 1A illustrates a configuration of a comparison embodiment for comparing with the present disclosure.

As shown in FIG. 1A, a position measuring apparatus for measuring a position of a pen according to the comparison embodiment includes an electrode unit **110** and a coil unit **140**. The electrode unit **110** includes one or more electrodes **121**, **122**, **123**, **131**, **132** and **133**. The coil unit **140** includes one or more coils **151**, **152**, **153**, **161**, **162** and **163**. Here, the electrode unit **110** is for measuring a position of a finger of a user, and the coil unit **140** is for measuring the position of the pen.

As shown in FIG. 1A, the electrode unit **110** may include electrodes **131**, **132** and **133** extending in an x-axis direction for measuring a y-axis coordinate of the finger and electrodes **121**, **122** and **123** extending in a y-axis direction for measuring an x-axis coordinate of the finger. The extension in the x-axis direction may mean that the length of an electrode in the x-axis direction is longer than that of the electrode in the y-axis direction. The extension in the y-axis direction may mean that the length of the electrode in the y-axis direction is longer than that of the electrode in the x-axis direction.

One electrode of the electrode unit **110** has a predetermined capacitance. When a user touches one point using a finger, the predetermined capacitance of the electrode unit may be changed. The position measuring apparatus by the comparison embodiment may measure the position of the finger of the user based on the changed capacitance.

As shown in FIG. 1A, the coil unit **140** may include coils **161**, **162** and **163** extending in an x-axis direction for measuring a y-axis coordinate of a pen and coils **151**, **152** and **153** extending in a y-axis direction for measuring an x-axis coordinate of the pen. Here, the extension in the x-axis direction may mean that a length of a coil in the x-axis direction is longer than that of the coil in the y-axis direction.

The extension in the y-axis direction may mean that the length of the coil in the y-axis direction is longer than that of the coil in the x-axis direction.

As shown in FIG. **1**B, the position measuring apparatus by the comparison embodiment may apply a current i**1***a* to the second coil **152**. The second coil **152** may form an induced magnetic field B**1***a*. A pen **100** by the comparison embodiment may include a resonance circuit **101**. The resonance circuit **101** may generate a resonance by the induced magnetic field B**1***a*. An electromagnetic wave may be generated by the generated resonance. As shown in FIG. **1**C, the resonance circuit **101** of the pen **100** by the comparison embodiment may output a magnetic field B**1***b*.

The first coil **151** may generate an induced electromotive current i**1***b* by the magnetic field B**1***b* output from the pen **100**. An intensity of the magnetic field B**1***b* output from the pen **100** may be reduced in inverse proportion to a square of a distance from a generation point. When the intensity of the magnetic field B**1***b* output from the pen **100** is P and a distance from the pen **100** to the first coil **151** is r**1**, the intensity of the magnetic field B**1***b* at the first coil **151** is $P/r1^2$. In addition, the induced electromotive current i**1***b* at the first coil **151** may be in proportion to $P/r1^2$ which is the intensity of the magnetic field B**1***b* at the first coil **151**. When the intensity of the magnetic field B**1***b* output from the pen **100** is P and a distance from the pen **100** to the second coil **152** is r**2**, the intensity of the magnetic field B**1***b* at the second coil **152** is $P/r2^2$. In addition, an induced electromotive current i**1***c* at the second coil **152** may be in proportion to $P/r2^{2\prime}$ which is the intensity of the magnetic field B**1***b* at the second coil **152**. When the intensity of the magnetic field B**1***b* output from the pen **100** is P and a distance from the pen **100** to the third coil **153** is r**3**, the intensity of the magnetic field B**1***b* at the third coil **153** is $P/r3^2$. In addition, an induced electromotive current i**1***d* at the third coil **153** may be in proportion to $P/r3^2$ which is the intensity of the magnetic field B**1***b* at the third coil **153**. Therefore, the closer the distance between the pen and the coil is, the larger the formed induced electromotive current is. The position measuring apparatus by the comparison embodiment may measure the position of the pen **100** using intensities of induced electromotive currents at each coil.

The position measuring apparatus by the comparison embodiment may determine whether a type of a touched object is a pen or a finger. For example, when a change of a capacitance at the electrode unit **110** is detected, the position measuring apparatus by the comparison embodiment may determine that the finger is touched and determine a position of the finger. In addition, when an induced electromotive current is detected at the coil unit **140**, the position measuring apparatus may determine that the pen is touched and may determine the position of the pen.

As described above, the position measuring apparatus by the comparison embodiment should include both of the electrode unit **110** for determining the position of the finger and the coil unit **140** for measuring the position of the pen. Therefore, the whole thickness of the position measuring apparatus is increased. In addition, the position measuring apparatus may have problems, such as an increase of the calculation amount of a driving algorithm and an increase of a driving power, because both of the electrode unit **110** and the coil unit **140** should be driven. Specially, the manufacturing cost of a whole position measuring apparatus may increase according to a manufacturing cost of the coil.

FIG. **2**A illustrates a panel **210** of a position measuring apparatus for measuring the positions of a pen and a finger by a comparison embodiment for comparing with the present disclosure.

As shown in FIG. **2**A, the panel **210** of the position measuring apparatus for measuring the positions of the pen and the finger by the comparison embodiment includes an electrode unit and a coil **240**. The electrode unit includes one or more electrodes **221**, **222**, **223**, **231**, **232** and **233**. Here, the electrode unit is for measuring the positions of the finger of a user and the pen, and the coil **240** is for measuring the position of the pen. The electrode unit and the coil **240** may be formed on the same substrate.

As shown in FIG. **2**A, the electrode unit may include electrodes **231**, **232** and **233** extending in an x-axis direction for measuring a y-axis coordinate of the finger and electrodes **221**, **222**, and **223** extending in a y-axis direction for measuring an x-axis coordinate of the finger. The extension in the x-axis direction may mean that the length of an electrode in the x-axis direction is longer than that of the electrode in the y-axis direction. The extension in the y-axis direction may mean that the length of the electrode in the y-axis direction is longer than that of the electrode in the x-axis direction. Meanwhile, a configuration for determining the position of the finger of the user is described with reference to FIG. **1**A, and thus further descriptions concerning the configuration for determining the position of the finger of the user will be omitted.

As shown in FIG. **2**A, the coil **240** may be formed of one pattern. That is, the coil **240** may be formed of one pattern in a whole panel **210** on the contrary to the forming of the plurality of coils corresponding to each channel in the comparison embodiment of FIG. **1**A.

As shown in FIG. **2**B, the position measuring apparatus by the comparison embodiment may apply a current i**2***a* to the coil **240**. In the FIG. **2**B, for a convenience of description, an illustration of the electrode unit is omitted. The coil **240** may form an induced magnetic field B**2***a*. A pen **260** by the comparison embodiment may include a resonance circuit **261** and **262**. The resonance circuit **261** and **262** may generate a resonance by the induced magnetic field B**2***a*. An electromagnetic wave may be generated by the generated resonance. As shown in FIG. **2**C, the resonance circuit **261** and **262** of the pen **260** by the comparison embodiment may output electric fields E**2***a*, E**2***b* and E**2***c*. In FIG. **2**B, for a convenience of description, illustrations of the electrodes **241** to **243** and the coil **240** are omitted. The resonance circuit **261** and **262** of the pen **260** by the comparison embodiment may be connected to a ground **264**.

A conductive tip **263** of the pen **260** by the comparison embodiment may form a first capacitance C**2***a* with the first electrode **231**. The conductive tip **263** of the first electrode **231** and the pen **260** may form a capacitive coupling. The conductive tip **263** of the pen **260** may form a second capacitance C**2***b* with the second electrode **232**. The conductive tip **263** of the pen **260** may form a third capacitance C**3***b* with the third electrode **233**. A capacitance may be inverse proportion to a distance between two conductors of a capacitor. Thus, the first to third capacitances C**2***a*, C**2***b* and C**2***c* may be different. In addition, each size of each electric fields E**2***a*, E**2***b* and E**2***c* transferred through the first to third capacitances C**2***a*, C**2***b* and C**2***c* are different.

The electrode **231**, **232** and **233** may output currents corresponding to the transferred electric fields E**2***a*, E**2***b* and E**2***c*, respectively. Since each size of the transferred electric fields E**2***a*, E**2***b* and E**2***c* is different, the currents output from the electrodes **231**, **232** and **233** may be also different. The position measuring apparatus by the comparison embodiment determines the position of the pen based on the currents from each of the electrodes **231**, **232** and **233**.

More specifically, the first electrode **231** may generate the current by the electric field E2*a* output from the pen **260**. An intensity of the electric field E2*a* output from the pen **260** may be reduced in inverse proportion to a square of a distance from a generation point. When the intensity of the electric field E2*a* output from the pen **260** is Q and a distance from the pen **260** to the first electrode **231** is r1, the intensity of the electric field E2*a* at the first electrode **231** is $Q/r1^2$. In addition, the current at the first electrode **231** may be in proportion to $Q/r1^2$ which is the intensity of the electric field E2*a* at the first electrode. When the intensity of the electric field E2*a* output from the pen **260** is Q and a distance from the pen **260** to the second electrode **232** is r2, the intensity of the electric field E2*a* at the second electrode **232** is $Q/r2^2$. In addition, the current at the second electrode **232** may be in proportion to $Q/r2^2$, which is the intensity of the electric field E2*a* at the second electrode. When the intensity of the electric field E2*a* output from the pen **260** is Q and the distance from the pen **260** to the third electrode **233** is r3, the intensity of the electric field E2*a* at the third electrode **233** is $Q/r3^2$. In addition, the current at the third electrode **233** may be in proportion to $Q/r3^2$, which is the intensity of the electric field E2*a* at the third electrode. Therefore, the closer the distance between the pen and the electrode is, the larger the output current is. The position measuring apparatus by the comparison embodiment may measure the position of the pen using intensities of currents from each electrodes **231**, **232** and **233**.

The position measuring apparatus by the comparison embodiment may determine whether a type of a touched object is a pen or a finger. For example, when a change of the capacitance at the electrode unit is detected, the position measuring apparatus by the comparison embodiment may determine that the finger is touched and determine the position of the finger. In addition, when a current from the electrode unit is detected, the position measuring apparatus may determine that the pen is touched and determine a position of the pen.

FIG. **3** illustrates a panel of a position measuring apparatus capable of determining a position of a pen according to various embodiments of the present disclosure. The position measuring apparatus may measure a touched position or a proximity position of a touched object such as a pen or a finger. In addition, the position measuring apparatus may further measure a pen pressure of a pen, button on and off states and the like, and these are described in more detail later.

As shown in FIG. **3**, the panel of the position measuring apparatus according to various embodiments of the present disclosure includes an electrode unit including one or more electrodes **321**, **322**, **323**, **331**, **332** and **333**. On the contrary to the comparison embodiments of FIGS. **1**A and **2**B, the position measuring apparatus by an embodiment of FIG. **3** may not include a coil. Meanwhile, a pen **360** by various embodiments of the present disclosure may include a resonance circuit **361** and **362**, a conductive tip **363** and a ground **363**.

FIG. **4**A illustrates a plan view of an electrode arrangement of a position measuring apparatus according to various embodiments of the present disclosure.

As shown in FIG. **4**A, the position measuring apparatus may include electrodes **321**, **322** and **323** extending in an x-axis direction for measuring a y-axis coordinate of a pen and electrodes **331**, **332**, and **333** extending in a y-axis direction for measuring an x-axis coordinate of the pen. The extension in the x-axis direction may mean that the length of an electrode in the x-axis direction is longer than that of the electrode in the y-axis direction. The extension in the y-axis direction may mean that the length of the electrode in the y-axis direction is longer than that of the electrode in the x-axis direction. The electrodes may be connected to a control unit **410** of the position measuring apparatus.

As shown in FIG. **4**B, the electrodes **321**, **322**, **323**, **331**, **332** and **333** may be connected to a driving unit. The electrodes may be connected to the driving unit **420** through a switch **425**. The control unit **410** may apply a current to the **321**, **322**, **323**, **331**, **332** and **333** by controlling the driving unit **420**. The control unit **410** may control the switch **425** connected to the driving unit **420** such that the switch **425** is connected to the electrodes **321**, **322**, **323**, **331**, **332**, and **333**. The electrode connected to the driving unit **420** may be referred to as a driving electrode. The driving electrode may receive a current, which is a driving signal, from the driving unit **420**. The driving electrode may generate an electric field based on the driving signal.

The electrodes **321**, **322**, **323**, **331**, **332** and **333** may be connected to a receiving unit **430**. The electrodes **321**, **322**, **323**, **331**, **332** and **333** may be connected to the receiving unit **430** through a switch **435**. The control unit **410** controls the switch **435** such that the receiving unit **430** is connected to the electrodes **321**, **322**, **323**, **331**, **332** and **333**. The receiving unit **430** may process a signal received from the connected electrode, and the control unit **410** may measure a position of the pen **460** using the processed signal. The electrodes **321**, **322**, **323**, **331**, **332** and **333** may receive the electric field, that is a received signal, output from the pen **460**. The electrodes **321**, **322**, **323**, **331**, **332** and **333** may output a current corresponding to the received electric field, and the receiving unit **430** may process the output current and transfer the processed current to the control unit **410**.

FIG. **5**A illustrates a conceptual diagram of a pen position measurement of a position measuring apparatus according to various embodiments of the present disclosure.

As shown in FIG. **5**A, the control unit **410** may apply a driving signal to a driving electrode **321** by controlling a switch **425** and a driving unit **420**. Meanwhile, the driving electrode **321** may form a capacitance C5*a* with a conductive tip **363** of a pen **360**. The driving electrode **321** may include a conductive material, and thus the driving electrode **321** may form the capacitance C5*a* with the conductive tip **363**. That is, the driving electrode **321** may form a capacitive coupling with the conductive tip **363**. The driving electrode **321** may transmit a transmission signal of an electric field E5*a* to the pen **360** based on the driving signal from the driving unit **420**. For example, the driving unit **420** may output a driving signal **701** to **706** as shown in (a) of FIG. **7** to the driving electrode **321**. The driving unit **420** may output the driving signal **701** to **706** during a first period, and may not output the driving signal during a second period **711** to **715**. More specifically, the driving unit **420** may output the driving signal **701** to **706** during a driving period T**1**, that is the first period, and may not output the driving signal during a non-driving period T**2**, that is the second period **711** to **715**. The driving unit **420** may repeat a driving signal control of the driving period and the non-driving period. Alternatively, the control unit **410** may control the switch **325** such that the driving unit **420** is connected to the driving electrode **321** during the first period and is not connected to the driving electrode **321** during the second period.

As shown in FIG. **5**B, the conductive tip **363** of the pen **360** may form a capacitance C5*b* with the fourth electrode

331. The conductive tip 363 may form a capacitance C5c with the fifth electrode 332, and may form a capacitance C5d with the sixth electrode 333. When the driving electrode 321 transmits the electric field E5a by the driving signal 701, the resonance circuit 361 and 362 of the pen 360 may generate a resonance. For example, the resonance circuit 361 and 362 of the pen 360 may generate a resonance 721 as shown in (b) of FIG. 7. (b) of FIG. 7 may show an electromagnetic wave, for example an electric field, by the resonance. As shown in (b) of FIG. 7, the electric field may be an alternating current form having a resonance frequency. An amplitude of the electric field may be increased during the period when the driving signal is applied, that is the first period. In addition, the amplitude of the electric field may be reduced during the period when the driving signal is not applied, that is the second period. The electric field by the resonance may be applied to the fourth electrode 331 during a first 711 of the second period. The fourth electrode 331 may output a current i5b corresponding to a received signal E5b. The receiving unit 430 may receive the current i5b and transfer the current i5b to the control unit 410. The control unit 410 may measure the position of the pen 360 using the received current i5b. A received signal 731 shown in (c) may be delayed by x2 compared to the driving signal 701, and thus the received signal 731 may be received during the non-driving period T2, that is the second period 711.

As shown in FIG. 5C, the conductive tip 363 of the pen 360 may form a capacitance C5c with the fifth electrode 332. When the driving electrode 321 transmits an electric field E5a by a driving signal 702, the resonance circuit 361 and 362 of the pen 360 may generate a resonance 722. The electric field by the resonance may be applied to the fifth electrode 332 as a received signal E5c like a second waveform 732 shown in (c) of FIG. 7. For example, the pen 360 may be more adjacent to the fifth electrode 332 compared to the fourth electrode 331. Thus, the second waveform 732 may have an amplitude higher than that of the first waveform 731. The fifth electrode 332 may output a current i5c corresponding to the received signal E5b. The receiving unit 430 may receive the current i5c and transfer the current i5c to the control unit 410. The control unit 410 may measure the position of the pen 360 using the received current i5c.

As shown in FIG. 5D, the conductive tip 363 of the pen 360 may form a capacitance C5d with the sixth electrode 333. When the driving electrode 321 transmits an electric field E5a by a driving signal 703, the resonance circuit 361 and 362 of the pen 360 may generate a resonance 723. The electric field by the resonance may be applied to the sixth electrode 333 as a received signal E5c like a third waveform 733 shown in (c) of FIG. 7. For example, the pen 360 may be more adjacent to the sixth electrode 333 compared to the fifth electrode 332. Thus, the third waveform 733 may have an amplitude higher than that of the second waveform 732. The sixth electrode 333 may output a current i5d corresponding to the received signal E5d. The receiving unit 430 may receive the current i5d and transfer the current i5d to the control unit 410. The control unit 410 may measure the position of the pen 360 using the received current i5d.

The control unit may determine the position of the pen 360 using the currents i5b to i5d received from each of the fourth to sixth electrodes 331 to 333. For example, the control unit 410 may determine an electrode of which a received current is highest as the position of the pen. Alternatively, the control unit may apply an interpolation to the received current to determine the position of the pen based on the application result. Meanwhile, in the above, a configuration in which the control unit 410 measures an x-axis position of the pen 360 is described, but it may be easily understood that this may be identically applied to a measurement of a y-axis position to a person having an ordinary skill in the art. In this case, one of the electrodes 331 to 333 for measuring the x-axis position may be set as the driving electrode.

According to the description above, the position measuring apparatus according to various embodiments of the present disclosure can determine the position of the pen using only an electrode without a coil. In addition, the position measuring apparatus can determine a touch position of a finger according to a capacitance change of an electrode when a user touches using a finger. Thus, the position measuring apparatus according to various embodiments of the present disclosure can measure input positions of the pen and the finger using a plurality of electrodes. Specially, as described above, when the pen is input, the position measuring apparatus may receive an alternating current waveform signal of an electric field form. When the finger touches the position measuring apparatus, an alternating current waveform signal may not be received. Thus, the position measuring apparatus can determine whether the pen is touched or the finger is touched according to whether a received current includes an alternating current waveform. Determining a type of a touched object will be described in more detail later.

FIG. 6 illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure. The embodiment of FIG. 6 will be described in more detail with reference to FIG. 7. FIG. 7 illustrates waveforms of a signal generated or measured by various embodiments of the present disclosure.

The position measuring apparatus may apply a driving signal to a driving electrode during the first period 701, 702, 703, 704, 705 and 706. For example, as shown in (a) of FIG. 7, the driving signal may be applied during the first period 701, 702, 703, 704, 705 and 706, that is a period T1. A driving electrode may transmit a transmission signal, for example an electric field, to the pen by the driving signal. In one embodiment, the driving electrode may transmit the electric field to the pen through a capacitive coupling formed between the driving electrode and a conductive tip of the pen. The driving signal is illustrated as a form of a square wave having an amplitude A during the period T1, but this is a simple example, and a waveform of the driving signal is not limited.

The position measuring apparatus may measure a received signal at the electrode during the second period 711, 712, 713, 714 and 715. For example, the pen may generate the resonances 721, 722, 723, 724, 725 and 726 like (b) of FIG. 7. More specifically, when the driving electrode transmits a transmission signal during the first period 701, the pen may generate a first resonance 721 corresponding to the transmission signal. As shown in (a) of FIG. 7, since the driving signal is applied during a first of the first period 701 and is not applied during a first of the second period 711, the first resonance 721 may have a waveform of which an amplitude increases and then decreases.

As shown in FIG. 7, a signal waveform of the resonance shown in (b) may be delayed by x1 compared to the driving signal shown in (a). In addition, the signal wave of the resonance may be applied to the position measuring apparatus like a waveform shown in (c) of FIG. 7. That is, the position measuring apparatus may receive received signals 731, 732, 733, 734 and 735 from the pen. For example, a first received signal 731 may be received from an electrode of a first channel of the position measuring apparatus, and second to fifth received signals **732** to **735** may be received from second to fifth channels, respectively. As described above, the closer a distance between the electrode and the pen is, the stronger an intensity of the received signal is. In the embodiment of FIG. **7**, it is assumed that the pen is disposed adjacently to the third channel. Thus, as shown in (c) of FIG. **7**, a size of the received signal **733** received from the third channel may be larger than that of other received signals **731**, **732**, **734** and **735**. The position measuring apparatus may determine the position of the pen based on received signals from electrodes corresponding to each channel. For example, the position measuring apparatus may determine the position of the pen based on the intensity of the received signal received from the electrode. The position measuring apparatus may determine the position of the pen based on a comparative intensity of the received signal received from the electrode.

In another embodiment, the position measuring apparatus may determine the position of the pen based on a capacitance of the electrode, which is changed by the touch of the pen. The position measuring apparatus may determine the position of the pen, and may determine whether the touched object is the pen or not based on the received signal. This will be described in detail later.

The individual waveforms shown in (c) of FIG. **7** may be received signals received from different electrode channels, respectively. Amplitudes of the individual waveforms shown in (c) of FIG. **7** may be different according to distances between the pen and each of the channels. Here, the received signal may be an electric field transferred through a capacitive coupling formed between each of the individual electrodes and the conductive tip of the pen. Meanwhile, the received signals **731**, **732**, **733**, **734** and **735** may be delayed by x**2** compared to the driving signal shown in (a). For example, the received signal may be received during the non-driving period T**2**, that is the second period **711**, **712**, **713**, **714** and **715**, and the position measuring apparatus may measure the received signal during the second period **711**, **712**, **713**, **714** and **715**, that is the non-driving period T**2**.

The position measuring apparatus may determine the position of the pen based on the received signal measured during the second period. For example, the position measuring apparatus may determine the position of the pen based on the intensity of the received signals corresponding to each electrode channel like (c) of FIG. **7**. As described above, the closer a distance between the electrode and the pen is, the stronger an intensity of the received signal is. For example, in an embodiment of the FIG. **7**, the position measuring apparatus may determine that pen is adjacent to an electrode corresponding to the third received signal **733**.

FIG. **8** illustrates a flowchart of a pen position measuring method according to various embodiments of the present disclosure.

In step **810**, a position measuring apparatus **801** may apply a driving signal to an electrode during a first period. The position measuring apparatus **801** may include a plurality of electrodes for measuring the pen position, and may apply the driving signal to a driving electrode among the plurality of electrodes. The position measuring apparatus **801** may determine a predetermined electrode as the driving electrode. Alternatively, the position measuring apparatus **801** may re-determine an electrode corresponding to the determined pen position as the driving electrode for measuring a position of a next pen, and this will be described in more detail later.

In step **820**, the driving electrode may transfer a transmission signal to the pen **802** through a capacitive coupling formed between the driving electrode and the pen **802**. The driving electrode may form an electric field based on an applied current and the transmission signal of an electric field form may be transferred to the pen **802**.

In step **830**, the pen **802** may generate a resonance based on the transferred transmission signal of the electric field form. The pen **802** may include a resonance circuit, and may generate the resonance based on the transferred transmission signal. Thus, the pen **802** may generate an electromagnetic wave.

In step **840**, the pen **802** may transfer a received signal of an electric field form to the position measuring apparatus **801** through a capacitive coupling formed between each of the plurality of electrodes and the pen. In step **850**, the position measuring apparatus **801** may measure the received signals at each electrode corresponding to each channel. The position measuring apparatus **801** may measure the received signals at each electrode corresponding to each channel during a second period, that is a non-driving period. More specifically, the position measuring apparatus **801** may measure a received signal at an electrode of a first channel during a first of the non-driving period, and may measure a received signal at an electrode of a second channel during a second of the non-driving period. The position measuring apparatus **801** may measure received signals which are received from all electrodes included therein.

In step **850**, the position measuring apparatus **801** may determine the position of the pen based on the received signals which are received from the electrodes corresponding to each channel. The electrodes corresponding to each channel may generate currents based on the received signals, and the position measuring apparatus **801** may determine the position of the pen based on the currents generated from the electrodes corresponding to each channel. For example, the position measuring apparatus **801** may determine an electrode from which a current having a comparatively large size is generated as the position of the pen. The position measuring apparatus **801** may determine a y-axis position of the pen based on currents generated from electrodes extending in an x-axis direction and may determine an x-axis position of the pen based on currents generated from electrodes extending in a y-axis direction.

FIG. **9** illustrates a block diagram of a position measuring apparatus and a pen according to various embodiments of the present disclosure.

As shown in FIG. **9**, a position measuring apparatus **910** may include a control unit **911**, a driving unit **912**, an electrode unit **913** and a receiving unit **914**. In addition, a pen **920** may include a conductive tip **921** and a resonance unit **922**.

The control unit **911** may control the driving unit **912** such that the driving unit **912** provides a driving signal during a first period. The control unit **911** may control the driving unit **912** such that the driving unit **912** is connected to a driving electrode of an electrode unit **913**. The driving electrode may generate an electric field based on the driving signal transferred from the driving unit **912** during the first period. The driving electrode of the electrode unit **913** may form a capacitive coupling with a conductive tip **921** of the pen **920**. The driving electrode may transmit a transmission signal of an electric field form to the pen **920** through a capacitive coupling.

The resonance unit **922** of the pen **920** may generate a resonance based on the transmission signal of the electric field form from the driving electrode. An electric field may be generated by the resonance, and the electric field, that is a received signal may be transferred through the capacitive coupling formed between the electrode of the electrode unit and the conductive tip **921**.

The receiving unit **914** may process the received signals which are received from each electrode of the electrode unit and transmit the processed received signals to the control unit **911**. The control unit **911** may control the receiving unit **914** and the driving unit **912** such that the receiving unit **914** is connected to the electrode unit **913** during a second period different from the first period and the driving unit **912** is not connected to the electrode unit **913** during the second period. That is, the control unit **911** may not apply the driving signal to the electrode unit during the second period. Each of electrodes of the electrode unit **913** may output currents to the receiving unit **914** based on the received signals. The receiving unit **914** may perform, for example, an amplification, a noise elimination, a digital conversion, a conversion into a signal on a frequency area and the like for the received signal or the currents, and these will be described in more detail later.

The control unit **911** may measure the position of the pen based on the received signals or the currents from each electrode of the electrode unit **913**. In one embodiment, the control unit **911** may determine a position of a channel electrode of which a received signal or a current is the largest among the received signals or currents from each electrode as the position of the pen. In addition, the control unit **911** may also determine the position of the pen based on a comparative size of the received signals or currents received from each electrode. In addition, the control unit **911** may also determine the position of the pen based on an interpolation result for the received signals or currents from each electrode.

FIG. **10**A is a conceptual diagram of a pen according to various embodiments of the present disclosure.

As shown in FIG. **10**A, a pen **1000** may include a conductive tip **1010**, a resonance circuit unit **1020** and a ground unit **1040**. An end of the conductive tip **1010** is connected to an end of the resonance circuit unit **1020**. In addition, another end of the resonance circuit **1020** may be connected to the ground unit **1040**. The pen **1000** may be implemented as, for example, a pen shape.

The conductive tip **1010** may form a capacitance **1013** with an electrode **1012** in a position measuring apparatus. The conductive tip **1010** may form, for example, a metallic tip, and may form the capacitance **1013** with at least one electrode **1012**. The conductive tip **1010** may be in nonconductive material or a portion of the conductive tip **1010** may be exposed to the outside thereof. In addition, the electrode **1012** may be formed of a transparent electrode at a lower end of a transparent window **1011** so as to be applied to a touch screen.

The resonance circuit unit **1020** may resonate to a transmission signal input from the position measuring apparatus. The resonance circuit unit **1020** may output a resonance signal by the resonance after the input of the transmission signal is stopped. The resonance circuit unit **1020** may output a sine waveform signal having a resonance frequency of the resonance circuit **1020**. In an embodiment of the present disclosure, a sine waveform signal having a specific resonance frequency may be pen identification information.

That is, the position measuring apparatus may determine that a type of a touched object is the pen when the sine waveform signal having the specific resonance frequency is included in the received signal.

Meanwhile, according to another embodiment of the present disclosure, the resonance frequency of the resonance circuit unit **1020** may be changed according to a touch pressure of the conductive tip **1010**. For example, when a user touches using the pen, the resonance frequency of the resonance circuit unit **1020** may be changed. Thus, the position measuring apparatus may determine a pen pressure based on a change of the resonance frequency. In addition, the resonance circuit unit **1020** may further include a resistor connected thereto in parallel. The resistor may be a variable resistor, and a resonance attributes may be changed according to a change of a resistance. In addition, the pen may further include a switch unit which may be mechanically operated by a user. The resonance attributes of the pen may be changed according to a state of the switch unit. Thus, the user may input, for example, writing and erasing functions, on the basis of on and off states of the switch unit.

FIG. **10**B illustrates a circuit configuration of the pen in FIG. **10**A according to various embodiments of the present disclosure. As shown in FIG. **10**B, the resonance circuit unit **1020** may include a coil **1021** and a capacitor **1022**.

FIG. **10**C is a cross-sectional view of a coordinate display apparatus according to an embodiment of the present disclosure.

As shown in FIG. **10**C, the pen may include a conductive tip **1010**, a ground unit **1030**, an insulating unit **1040** and a passive circuit unit **1070**.

The conductive tip **1010** may form a capacitance with electrodes in the position measuring apparatus. A portion of the conductive tip **1010** may be exposed to the outside of the pen as shown in FIG. **10**C. Meanwhile, in order to soften a sense of a writing when the pen is used, the pen may further include the insulating unit for preventing a direct contact between the conductive tip **1010** and the outside.

The passive circuit unit **1070** may be electrically connected to the conductive tip **1010**. The passive circuit unit **1070** may generate pen identification information. That is, the passive circuit unit **1070** may differentiate physical attributes of the pen from attributes of the finger. In one embodiment, the passive circuit unit **1070** may include a device which receives an electric field and outputs an electric field or a magnetic field having a predetermined frequency corresponding to the electric field. For example, in FIG. **10**A, the resonance circuit unit is described as an example of the passive circuit unit **1070**.

The insulating unit **1040** may insulate the conductive tip **1010** from the ground unit **1030**. If, the insulating unit **1040** has a function of insulating the conductive tip **1010** from the ground unit **1030**, a shape of the insulating unit is not limited. The ground unit **1030** may be connected to the passive circuit unit **1070**, and may be electrically connected to a user or the coordinate measuring apparatus through at least one of a direct contact and a capacitive coupling.

FIG. **10**D illustrates a circuit diagram of the pen in FIG. **10**A according to various embodiments of the present disclosure. As shown in FIG. **10**D, a resonance circuit unit **1015** may include a coil **1016**, a capacitor **1017** and a variable capacitor **1018** connected each other in parallel. That is, the resonance circuit may further include the coil **1016** and two capacitors **1017** and **1018**. Meanwhile, it is illustrated that the variable capacitor **1018** is connected to the capacitor **1017** in parallel, but this is a simple example.

A conductive tip **1010** may form a capacitance with electrodes in a position measuring apparatus. The resonance circuit unit **1015** may be electrically connected to the conductive tip **1010**. The resonance circuit unit **1015** may generate and output pen identification information. For example, the resonance circuit unit **1015** may generate a resonance based on a received electric field and output an electric field or a magnetic field having a predetermined frequency. That is, the resonance circuit unit **1015** may differentiate physical attributes of the pen from attributes of the finger.

In addition, a variable impedance **1018** may include a device of which an impedance may be changed due to at least one of a touch pressure and a touch-or-not between the pen **1000** and the position measuring apparatus. Since the variable impedance **1018** provides the impedance which is changed by at least one of the touch pressure and user selection switch on and off, resonance attributes may be changed according to the touch pressure and the user selection switch on and off.

The position measuring apparatus may determine at least one state of the touch pressure of the pen **1000** and the user selection switch on and off based on the changed resonance attributes. The variable impedance of this time may include a reactance or a resistance component which is changed according to the touch pressure or the user selection switch on and off. Meanwhile, the resonance circuit unit **1015** may have high-impedance attributes at a specific resonance frequency. Therefore, the position measuring apparatus may receive the received signals having different frequencies from the pen **1000** according to different touch pressures between the pen **1000** and the position measuring apparatus. More specifically, when the frequency of the received signal which is received from the pen **1000** by the position measuring apparatus is f**1**, the position measuring apparatus may determine the touch pressure is P**1**. In addition, when the frequency of the received signal which is received from the pen **1000** by the position measuring apparatus is f**2**, the position measuring apparatus may determine the touch pressure is P**2**.

It is assumed that an inductance of the coil **1016** is L**1** and a capacitance of the capacitor **1017** is C**1**. In various embodiments, the variable impedance **1018** may be implemented as a variable capacitor. It is assumed that the capacitance of the variable impedance **1018** is C**2**. The resonance frequency of the pen **1000** may be

$$\frac{1}{2\pi\sqrt{L1(C1+Cm)}},$$

and the resonance frequency may be changed according to a change of Cm. In one embodiment, the capacitance Cm of the variable impedance **1018** may be changed according to a change of the touch pressure. For example, the position measuring apparatus may store information in which the capacitance Cm of the variable impedance **1018** is C**2** when a pressure is P**1** and the capacitance Cm of the variable impedance **1018** is C**3** when a pressure is P**2**. Therefore, when the frequency of the received signal from the pen **1000** is

$$\frac{1}{2\pi\sqrt{L1(C1+C2)}},$$

the position measuring apparatus may determine the touch pressure is P**1**, and when the frequency of the received signal from the pen **1000** is

$$\frac{1}{2\pi\sqrt{L1(C1+C3)}},$$

the position measuring apparatus may determine the touch pressure is P**2**.

FIG. **10**E is a conceptual diagram of a pen according to various embodiments of the present disclosure.

As shown in FIG. **10**E, the pen may include a conductive tip **1010**, a coil unit **1021**, a capacitor unit **1022**, a switch unit **1013** and a ground unit **1040**.

The conductive tip **310** may form a capacitance with electrodes in a coordinate measuring apparatus (not shown). The coil unit **1021** and the capacitor unit **1022** may form a parallel resonance circuit. Since the coil unit **1021** and the capacitor unit **1022** form the resonance circuit, the pen may output a resonance signal.

The switch unit **1013** may be connected to an end of the coil unit **1021** and an end of the capacitor unit **1022**. The switch unit **1013** may be mechanically operated. The resonance attributes may be changed on the basis of on and off states of the switch unit **1013**. For example, when the switch unit **1013** is the off state, the conductive tip **1010** may be disconnected from the resonance circuit, and when the switch unit **1013** is the on state, the conductive tip **1010** may be connected to the resonance circuit. As an embodiment such a configuration, when the conductive tip **1010** touches in a pressure equal to or higher than a predetermined critical value, the switch unit **1013** may form the resonance circuit, and when the conductive tip **1010** touches in a pressure lower than the predetermined critical value, the switch unit **1013** may disconnect an electrical connection so as not to form the resonance circuit. The position measuring apparatus may recognize an input only when the pen **1000** touches the position measuring apparatus in the pressure equal to or higher than the critical value, and thus an input of the pen due to a mistake can be effectively reduced.

FIG. **10**F is a cross-sectional view of a pen according to an embodiment of the present disclosure.

As shown in FIG. **10**F, the pen may include a conductive tip **1010**, a ground unit **1030**, an insulating unit **1040**, a resonance circuit unit **1070** and a switch unit **1090**. The pen shown in FIG. **10**F may further include the switch unit **1090** compared to the coordinate display apparatus of FIG. **10**C. The switch unit **1090** may be electrically connected between the conductive tip **1010** and the resonance circuit unit **1070**. In relation to FIG. **10**G, the switch unit **1090** may operate a resonance circuit only when the conductive tip **1010** touches in a pressure equal to or higher than a predetermined critical value as described above.

FIG. **11**A illustrates a conceptual diagram of a panel of a position measuring apparatus according to various embodiments of the present disclosure. As shown in FIG. **11**A, the position measuring apparatus may include a panel **1110** including a plurality of electrodes **1111** to **1115**. For a convenience of description, only the electrodes **1111** to **1115** extending in a y-axis direction for determining an x-axis position are illustrated, and a person having an ordinary skill in the art may easily understand that an electrode (not shown) extending in an x-axis direction may be included in the position measuring apparatus. Here, it is assumed that a finger touches a third electrode **1113**.

A driving unit may apply driving signals **1121** to **1125** as shown in (a) of FIG. **11**B to a driving electrode. Here, the driving electrode may be one of electrodes extending in the x-axis direction. The position measuring apparatus may apply a first driving signal to the driving electrode. For example, the position measuring apparatus may apply the first driving signal **1121** to the driving electrode. The position measuring apparatus may apply the first driving signal **1121** to the driving electrode during a driving period T**1** and apply the second driving signal **1122** to the driving electrode during the driving period T**1** after a non-driving period T**2**. Each of the driving signals **1121** to **1125** may have an amplitude A.

Meanwhile, (b) of FIG. **11**B illustrates received signals **1131** to **1135** measured at the plurality of electrodes **1111** to **1115**, respectively. For example, the first received signal **1131** measured at the first electrode **1111** may have an amplitude C**1**, and this may be lower than a reference amplitude S by Δ**11**. Table 1 below shows the received signals **1131** to **1135** which are received from each of the electrodes **1111** to **1115**.

TABLE 1

	Electrode				
	First electrode (1111)	Second electrode (1112)	Third electrode (1113)	Fourth electrode (1114)	Fifth electrode (1115)
Amplitude	C1	C2	C3	C4	C5
Change amount	Δl1	Δl2	Δl3	Δl4	Δl5

In an embodiment of FIGS. **11**A and **11**B, the amplitude C**3** at the third electrode **1113** may be the least, that is, the change amount (Δ**13**) at the third electrode **1113** may be the largest. That is, the position measuring apparatus may determine an electrode of which the change amount at the third electrode **1113** is the largest as an electrode of which a capacitance change is the largest. When a finger touches a specific coordinate, a capacitance of an electrode corresponding to the specific coordinate or a capacitance between an electrode and adjacent electrodes may be changed. An intensity of an Rx signal may be changed based on the capacitance change, the position measuring apparatus may determine an electrode of which the capacitance change is the largest as a touch point of the finger. Thus, the position measuring apparatus may determine the third electrode **1113** as an electrode where the finger touches. As described above, the position measuring apparatus may determine a touch point based on the received signals from each of the electrodes **1131** to **1135** during the driving period T**1** of the driving signal or currents from each of the electrodes **1131** to **1135**.

FIG. **12**A illustrates a conceptual diagram of a case in which a pen according to various embodiments of the present disclosure touches a panel.

As shown in FIG. **12**A, it is assumed that the pen touches a third electrode **1113**. FIG. **12**B illustrates a transmitted signal and a received signal when a pen according to various embodiments of the present disclosure touches.

A driving unit may apply driving signals **1221** to **1225** as shown in (a) of FIG. **12**B to a driving electrode. Here, the driving electrode may be one of electrodes extending in an x-axis direction. For example, a position measuring apparatus may apply a first driving signal **1221** to the driving electrode. The position measuring apparatus may apply the first driving signal **1221** to the driving electrode during a driving period T**1** and apply the second driving signal **1222** to the driving electrode during the driving period T**1** after a non-driving period T**2**. Each of the driving signals **1221** to **1225** may have an amplitude A. The driving electrode may generate an electric field based on the driving signals **1221** to **1225**.

The pen may generate resonances **1231** to **1235** based on the electric field received from the driving electrode as shown in (b) of FIG. **12**B.

(c) of FIG. **12**B illustrates received signals from each of the electrodes **1111** to **1115**. First, received signals **1241** to **1245** the same as those in the case in which the finger touches the third electrode **1113** may be measured during the first period. The third electrode **1113** may have the largest capacitance change due to the touch to the third electrode **1113** by the pen Thus, the received signal **1243** from the third electrode **1113** may have the least amplitude as shown in (c) of FIG. **12**B during even the first period. The position measuring apparatus may determine the third electrode from which the received signal **1243** is the least as an electrode of which a capacitance change is the largest, that is a touch electrode.

Received signals **1251** to **1255** may be received from pen as shown in (c) of FIG. **12**B during even the second period. The received signals **1251** to **1255** are an electric field by a resonance generated from the pen, the received signals **1251** to **1255** may have alternating current forms.

The position measuring apparatus may determine a touch point of the pen based on the received signals **1241** to **1245** during the first period, that is the driving period, from each of the electrodes **1111** to **1115**. In addition, the position measuring apparatus may determine that a touched object is the pen based on the received signals **1251** to **1255** during the second period, that is the non-driving period. As shown in FIG. **11**B, when the finger touches, any signal may not be received during the second period. Thus, the position measuring apparatus may determine a type of the touched object as one of the pen and the finger based on a measurement-or-not of the received signal or an existence-or-not of an alternating current waveform during the second period, that is the non-driving period.

FIGS. **13**A and **13**B illustrate a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure.

First, referring to FIG. **13**A, in step **1301**, the position measuring apparatus may apply a driving signal to a driving electrode during a driving period, that is a first period. The driving electrode may generate an electric field based on the driving signal during the driving period.

In step **1303**, the position measuring apparatus may measure a received signal measured at an electrode during the driving period. Alternatively, the position measuring apparatus may measure a current output from the electrode during the driving period.

In step **1305**, the position measuring apparatus may determine whether a capacitance of the electrode is changed during the driving period. For example, the position measuring apparatus may determine whether the capacitance is changed based on an amplitude or a change amount of the received signal or the current measured at the electrode. The position measuring apparatus may determine an input point based on the capacitance change. In one embodiment, the position measuring apparatus may determine an electrode of which a capacitance change is the largest as the input point. In another embodiment, the position measuring apparatus may also determine a point where a capacitance change is the largest by an interpolation result for the capacitance change.

In step **1307** and **1309**, the position measuring apparatus may determine whether the received signal is measured during a non-driving period, that is a second period. When it is determined that the received signal is measured during the non-driving period, in step **1311**, the position measuring apparatus may calculate the input point based on an intensity of the received signal which is measured during the non-driving period in step of **1310**. In step **1311**, the position measuring apparatus may determine that the pen touches the input point calculated in step **1311** and outputs the position of the pen. When it is determined that the received signal is not measured during the non-driving period, in step **1315**, the position measuring apparatus may determine that the finger touches an input point determined based on the capacitance change.

Next, referring to FIG. **13**B, in step **1321**, the position measuring apparatus may apply a driving signal to a driving electrode during a driving period, that is a first period. The driving electrode may generate an electric field based on the driving signal during the driving period.

In step **1323**, the position measuring apparatus may measure a received signal measured at an electrode during the driving period. Alternatively, the position measuring apparatus may measure a current output from the electrode during the driving period.

In step **1325**, the position measuring apparatus may determine whether a capacitance of the electrode is changed during the driving period. For example, the position measuring apparatus may determine whether the capacitance is changed based on an amplitude or a change amount of the received signal or the current measured at the electrode. The position measuring apparatus may determine an input point based on the capacitance change. In one embodiment, the position measuring apparatus may determine an electrode of which a capacitance change is the largest as an input point. In another embodiment, the position measuring apparatus may also determine a point where a capacitance change is the largest by an interpolation result for the capacitance change.

In step **1327**, the position measuring apparatus may determine whether the received signal is measured during a non-driving period, that is a second period. When it is determined that the received signal is measured during the non-driving period, in step **1331**, the position measuring apparatus may determine that the pen touches an input point calculated in step **1325**. Meanwhile, when it is determined that the received signal is not measured during the non-driving period, that is the second period, in step **1335**, the position measuring apparatus may determine that the finger touches an input point calculated in step **1325**. In step **1337**, the position measuring apparatus may output a finger touch point. In another embodiment, when the received signal includes an alternating current waveform during the non-driving period, the position measuring apparatus may determine that the pen touches. When the received signal does not include an alternating current waveform during the non-driving period, the position measuring apparatus may determine that the finger touches.

FIG. **14** illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure.

In step **1401**, the position measuring apparatus may apply a driving signal to a driving electrode during a first period, which is a driving period.

In step **1403**, the position measuring apparatus may measure received signals from each electrode during a non-driving period, which is a second period. Alternatively, the position measuring apparatus may measure currents from each electrode during the non-driving period.

In step **1405**, the position measuring apparatus may determine a type of a touched object based on response attributes of the received signal during the non-driving period. For example, when it is determined that the received signal during the non-driving period includes an alternating current waveform, the position measuring apparatus may determine that the touched object is a pen. In addition, when it is determined that the received signal during the non-driving period does not include an alternating current waveform, the position measuring apparatus may determine that the touched object is a finger. For example, the position measuring apparatus may convert the signal during the non-driving period into a signal on a frequency area and detect whether the signal includes a specific frequency, that is a resonance frequency component to determine whether the signal includes an alternating current waveform. Meanwhile, a person having an ordinary skill in the art may easily understand that a configuration of the position measuring apparatus which determines whether the signal includes an alternating current waveform is not limited.

Meanwhile, FIG. **15** is a block diagram for describing a method of measuring a resonance frequency change due to a pen pressure or switch on and off states according to an embodiment of the present disclosure.

A received signal may be amplified as much as a predetermined gain by an amplifying unit **1501**. A first switch unit **1502** may output a received signal amplified during a first period to an integral unit **1503**. Meanwhile, a second switch unit **1504** may output a received signal amplified during a second period to an integral unit **1505**.

The first period and the second period may be overlapped, but a whole of the first period and a whole of the second period may be not the same. The first switch unit **1502** and the second switch unit **1504** may be turned on and off at a fixed time based on a generation and a termination of a driving signal from a control circuit unit **1506**. In addition, in order to improve a received signal sensitivity, a rectifier and the like may be added.

The control circuit unit **1506** may measure frequency response attributes during different periods of the first period and the second period. Since a rate of a signal measured during each period may be different according to the frequency response attributes of a pen, the control circuit unit **1506** may determine a touch pressure of the pen or on and off states of the switch unit according to the rate of the signal measured during each period.

That is, the control circuit unit **1506** may measure the touch pressure or the switch on and off states based on the response attributes of a passive circuit of the pen during at least two different periods.

FIG. **16** illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure. The embodiment of FIG. **16** will be described in more detail with reference to FIGS. **17**A and **17**B. FIG. **17**A illustrates a conceptual diagram of a position measuring apparatus according to various embodiments of the present disclosure. FIG. **17**B illustrates a graph of received signals from electrodes corresponding to each channel according to various embodiments of the present disclosure.

In step **1601**, the position measuring apparatus may apply a driving signal to a driving electrode during a driving period.

As shown in FIG. **17**A, the position measuring apparatus may include one or more horizontal electrodes **1701** to **1706** and one or more vertical electrodes **1711** to **1716**. The horizontal electrodes **1701** to **1706** may be connected to a driving unit **1730** or a receiving unit **1740**. A first switch **1721** may be connected to one of the horizontal electrodes **1701** to **1706**. A third switch **1723** may connect one of the horizontal electrodes **1701** to **1706** with the driving unit **1730** or the receiving unit **1740**. A second switch **1722** may connect one of the vertical electrodes **1711** to **1716** to the receiving unit **1740**. The driving unit **1730** may be connected to a control unit **1750**, and the receiving unit **1740** may be connected to the control unit **1750**. The control unit **1750** may apply the driving signal to one driving electrode among the horizontal electrodes **1701** to **1706** by controlling the first switch **1721**.

The driving unit **1730** may generate the driving signal having a frequency difference within a predetermined critical value from a resonance frequency. The driving signal generated from the driving unit **1730** may be transferred to one driving electrode among the horizontal electrodes **1701** to **1706** through the first switch **1721**. One of the horizontal electrodes **1701** to **1706** may output an electric field to the outside based on the driving signal. Meanwhile, the horizontal electrodes **1701** to **1706** may form a capacitive coupling with a pen **1700**. Therefore, the electric field generated from the driving electrode among the horizontal electrodes **1701** to **1706** may be transferred to the pen **1700**. The pen **1700** may be resonated based on the transferred driving signal.

The driving unit **1730** may apply the driving signal to the driving electrode among the horizontal electrodes **1701** to **1706** during a first period, and may block the driving signal after the first period. The receiving unit **1740** may receive a resonance signal from the pen **1700** during a second period. The pen may generate a resonance signal based on energy accumulated in a resonance circuit during even a second period when the pen **1700** may not receive the electric field. The resonance signal generated from the pen **1700** may be transferred to each of the vertical electrodes **1711** to **1716** through a capacitive coupling formed between the pen **1700** and the vertical electrodes **1711** to **1716**. The receiving unit **1740** may receive the resonance signal received from the vertical electrodes **1711** to **1716**.

In step **1603**, the position measuring apparatus may measure the received signals from the electrodes corresponding to each channel, which are the resonance signals. The control unit **1750** may control operations of the driving unit **1730**, the receiving unit **1740** and first to third switches **1721** to **1723**. In addition, the control unit **1750** may measure a position and a type of the pen **1700** by processing the resonance signal from the receiving unit **1740**. For example, in step **1605**, the position measuring apparatus may determine an input point based on a comparative size of the received signals corresponding to each channel. This will be described in more detail with reference to FIG. **17**B.

FIG. **17**B illustrates a position relation between the pen **1700** and the vertical electrodes **1711** to **1716** according to various embodiments of the present disclosure.

As shown in FIG. **17**B, the pen **1700** may be positioned at an upper side of the third vertical electrode **1713**. A graph of FIG. **17**B illustrates intensities of resonance signals received from each of channels **1711***a* to **1716***a*. As shown in FIG. **17**B, a resonance signal intensity at a channel **1713***a* corresponding to the third vertical electrode **1713** is the largest. The closer a distance between the pen **1700** and an electrode, the larger a capacitance formed between the pen **1700** and the electrode, and thus the intensity of the resonance signal generated from the pen **1700** may be strongly received. Therefore, the farther a distance from the pen **1700** is, the more the size of the received resonance signal is reduced. Thus, the control unit **1750** may determine the position of the pen **1700** from a comparative size of the received signal.

Meanwhile, various noises in addition to the resonance signal generated from the pen **1700** may be simultaneously input to the vertical electrodes **1711** to **1716**. The input noise may disturb a calculation of an accurate touched position.

FIG. **18** illustrates a flowchart of a noise eliminating method of a position measuring apparatus according to various embodiments of the present disclosure. The embodiment of FIG. **18** will be described in more detail with reference to FIGS. **19**A to **19**D.

The position measuring apparatus according to various embodiments of the present disclosure may extract a signal of a resonance frequency area among received resonance signals. As described above, the resonance signal from the pen may have a resonance frequency. The position measuring apparatus according to various embodiments of the present disclosure may extract a signal of a resonance frequency band, and thus a Signal to Noise Ratio (SNR) may be improved.

In step **1801**, the position measuring apparatus may apply a driving signal to a driving electrode during a driving period. In step **1803**, the position measuring apparatus may measure received signals from each electrode corresponding to each channel during a non-driving period.

In step **1805**, the position measuring apparatus may amplify the received signal measured during the non-driving period. For example, as shown in FIG. **19**A, vertical electrodes **1711** to **1716** may be connected to an amplifier **1752** through a switch **1751**. The amplifier **1752** may amplify the received resonance signal and transfer the amplified resonance signal to an Analog to Digital Converter (ADC) **1753**.

In step **1807**, the ADC **1753** may convert the received resonance signal of an analog form to a digital signal. In step **1809**, a Digital Signal Processing (DSP) unit **1754** may perform a Fourier transform on the digital signal to convert the digital signal into a signal on a frequency area. In step **1811**, the DSP **1754** may extract a resonance frequency component or a band signal including a resonance frequency among the Fourier-transformed signals. More specifically, the DSP **1754** may extract a first range, that is 460 to 470 KHZ corresponding to a case in which a button of the pen is turned on and the pen has a pressure due to a touch between the pen and the position measuring apparatus. Alternatively, the DSP **1754** may extract a second range, for example 470 to 490 KHZ corresponding to a case in which the button of the pen is turned on. In addition, the DSP **1754** may extract a third range, for example 490 to 500 KHZ corresponding to a case in which the pen has a pressure due to the touch between the pen and the position measuring apparatus. In addition, the DSP **1754** may extract 500 KHZ corresponding to a case in which the pen is a floating input. The floating input is a state in which the pen is not contacted with the position measuring apparatus. The floating input may be referred to as a hovering input in some cases.

In step **1813**, the position measuring apparatus may determine an input point using the extracted component. Therefore, remaining noise except for the resonance signal may be excluded, and thus SNR may be improved.

FIG. **19**B illustrates a waveform in which a resonance signal and a noise are together received. FIG. **19**C illustrates a frequency area which is a Fourier transform result for an analog signal. As shown in FIG. **19**C, a signal **1991** and a noise **1992** may be included in a frequency area. A position measuring apparatus may perform a band pass filtering on a band **1993** including a resonance frequency in the frequency area.

FIG. **19**D may be a result obtained by extracting a specific band component related to a resonance frequency with respect to a Fourier transform. As shown in FIG. **19**D, a portion of a noise **1994** is remained, and thus an SNR can be improved.

FIG. **20** illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure. The embodiment of FIG. **20** will be described in more detail with reference to FIGS. **21**A and **21**B.

In step **2001**, a position measuring apparatus may apply a driving signal to a first electrode **2111** of FIG. **21**A. That is, the position measuring apparatus may determine the first electrode **2111** as a driving electrode and apply the driving signal to the first electrode **2111** during a driving period. As shown in FIG. **21**A, an electric field E**21***a* may be transferred through a capacitance C**21***a* formed between the first electrode **2111** and a pen **2120**. A second electrode **2112** may form a capacitance C**21***b* with the pen **2120**, and a third electrode **2113** may form a capacitance C**21***c* with the pen **2120**. In step **2003**, the position measuring apparatus may measure a received signal from the pen **2120**. In step **2005**, the position measuring apparatus may determine the third electrode **2113** as a position of the pen **2120** based on the received signal. The position measuring apparatus may measure received signals from each of the first to third electrodes **2111** to **2113**, and may determine the third electrode **2113** as the position of the pen **2120** based on the measured received signals.

In step **2007**, the position measuring apparatus may apply the driving signal to the third electrode **2113** of FIG. **21**B. That is, the position measuring apparatus may determine the third electrode **2113** as the driving electrode, and may apply the driving signal to the third electrode **2113** during the driving period. As shown in FIG. **21**B, an electric field E**21***b* may be transferred through the capacitance C**21***c* formed between the third electrode **2113** and the pen **2120**. Since the third electrode **2113** which is comparatively adjacent to the pen **2120** is updated as the driving electrode, a size of the electric field E**21***b* transferred from the driving electrode to the pen **2120** may be larger than that of the previous electric field E**21***a*.

In step **2009**, the position measuring apparatus may measure the received signal again. In step **2011**, the position measuring apparatus may determine the position of the pen based on the received signal. That is, the position measuring apparatus may update the driving electrode based on the determined position of the pen, and may use the updated driving electrode in measuring a position of a next pen.

FIG. **22**A illustrates a conceptual diagram of a position measuring apparatus that measures a position of a pen according to various embodiments of the present disclosure.

As shown in FIG. **22**A, the position measuring apparatus may include an electrode unit and a coil unit. The electrode unit includes one or more electrodes **2211**, **2212** and **2213**. The coil unit includes one or more coils **2221**, **2222** and **2223**. The electrode unit and the coil unit may be formed on one substrate. A position of the first electrode **2211** may correspond to the first coil **2221**, a position of the second electrode **2212** may correspond to the second coil **2222**, and a position of the third electrode **2213** may correspond to the third coil **2223**.

As shown in FIG. **22**B, a position measuring apparatus by a comparison embodiment may apply a driving signal to a driving electrode, for example, the second electrode **2212**. An electric field E**22***a* may be output by the driving signal applied to the second electrode **2212**. The second electrode, that is the driving electrode may a capacitance C**22***b* with a conductive tip of the pen. The second electrode **2212**, that is the driving electrode may output the electric field E**22***a* through the formed capacitance C**22***b*. Meanwhile, the first electrode **2211** may form a capacitance C**22***a* with the conductive tip of the pen, and the third electrode **2213** may form a capacitance C**22***c* with the conductive tip of the pen.

A pen **2260** by the various embodiments of the present disclosure may include a resonance circuit **2261** and **2262**. The resonance circuit **2261** and **2262** may generate a resonance by the electric field E**22***a*. An electromagnetic wave may be generated by the generated resonance. As shown in FIG. **22**C, the resonance circuit **2261** and **2262** of the pen **2260** by the embodiment may output a magnetic field B**22***a*.

The first coil **2221** may generate an induced electromotive current i**22***a* by the magnetic field B**22***a* output from the pen **2260**. An intensity of the magnetic field B**22***a* output from the pen **2260** may be reduced in inverse proportion to a square of a distance from a generation point. When the intensity of the magnetic field B**22***a* output from the pen **2260** is R and a distance from the pen **2260** to the first coil **2221** is r**1**, the intensity of the magnetic field B**22***a* at the first coil **2221** is $R/r1^2$. In addition, the induced electromotive current i**22***a* at the first coil **2221** may be in proportion to $R/r1^2$ which is the intensity of the magnetic field B**22***a* at the first coil **2221**. When the intensity of the magnetic field B**22***a* output from the pen **2260** is R and a distance from the pen **2260** to the second coil **2222** is r**2**, the intensity of the magnetic field B**22***a* at the second coil **2222** is $R/r2^2$. In addition, an induced electromotive current i**22***b* at the second coil **2222** may be in proportion to $R/r2^2$ which is the intensity of the magnetic field B**22***a* at the second coil **2222**. When the intensity of the magnetic field B**22***a* output from the pen **2260** is R and a distance from the pen **2260** to the third coil **2223** is r**3**, the intensity of the magnetic field B**22***a* at the third coil **2223** is $R/r3^2$. In addition, an induced electromotive current i**22***c* at the third coil **2223** may be in proportion to $R/r3^2$ which is the intensity of the magnetic field B**22***a* at the third coil **2223**. Therefore, the closer the distance between the pen and the coil is, the larger the formed induced electromotive current is. The position measuring apparatus by the comparison embodiment may measure the position of the pen **2260** using intensities of the induced electromotive currents i**22***a*, i**22***b* and i**22***c* at each of the coils **2221**, **2222** and **2223** during a non-driving period, that is a second period.

The position measuring apparatus by the embodiment may determine whether a type of a touched object is the pen **2260** or a finger. For example, when a change of a capacitance at the electrode unit is detected, the position measuring apparatus may determine that the finger is touched and determine a position of the finger. In addition, when an induced electromotive current is detected at the coil unit, the position measuring apparatus may determine that the pen **2260** is touched and determine a position of the pen.

FIG. **23** illustrates a configuration diagram of a position measuring apparatus according to various embodiments of the present disclosure.

A driving unit **2230** may be connected to a driving electrode among electrodes **2211**, **2212** and **2213** during a driving period, that is a first period. The driving unit **2230** may be connected to the driving electrode among the electrodes **2211**, **2212** and **2213** through a first switch **2231**. For example, when the first electrode **2211** is determined as the driving electrode, the first switch **2231** may connect the driving unit **2230** with the first electrode **2211** during the first period. A control unit **2250** may control the first switch **2231** and the driving unit **2230** such that the first switch **2231** connects the driving unit **2230** with the first electrode **2211** during the first period.

A receiving unit **2240** may process received signals which are received from each of coils **2221**, **2222** and **2223** or induced electromotive currents from each of coils **2221**, **2222** and **2223** and transfer processed received signals or induced electromotive currents to the control unit **2250**. For example, the receiving unit **2240** may perform an amplification, a noise elimination, a digital conversion, a conversion into a signal on a frequency area and the like for the received signal or the induced electromotive currents. A second switch **2241** may connect the receiving unit **2240** with the first coil **2221** during a first of a non-driving period, and thus the received signal or the induced electromotive current from the first coil **2221** may be transferred to the control unit **2250**. The second switch **2241** may connect the receiving unit **2240** with the second coil **2222** during a second of the non-driving period, and thus the received signal or the induced electromotive current from the second coil **2222** may be transferred to the control unit **2250**. A third switch **2243** may connect the receiving unit **2240** with the third coil **2223** during a third of the non-driving period, and thus the received signal or the induced electromotive current from the third coil **2223** may be transferred to the control unit **2250**. The control unit **2250** may control the connections between the second switch **2241** and the coils **2221**, **2222** and **2223**. Meanwhile, another ends of the coils **2221**, **2222** and **2223**, which are not connected to the switch **2241** may be grounded.

FIG. **24** illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure. The embodiment of FIG. **24** will be described in more detail with reference to FIG. **25**. FIG. **25** illustrates signals according to various embodiments of the present disclosure.

In step **2401**, as shown in (a) of FIG. **25**, a position measuring apparatus may apply driving signals **2501**, **2502**, **2503**,**2504**,**2505** and **2506** to a driving electrode during a first period T**1**, that is a driving period. The driving electrode may generate an electric field based on the applied driving signals **2501**, **2502**, **2503**, **2504**, **2505**, and **2506**. The electric field from the driving electrode may be transferred to a pen. The pen may generate resonances **2521**, **2522**, **2523**, **2524**, **2525** and **2526** as shown in (b) of FIG. **25** based on the transferred electric field, and an electromagnetic wave may be generated.

In step **2403**, the position measuring apparatus may measure received signals **2531**, **2532**, **2533**, **2534**, **2535**, and **2535** from coils during second periods **2511**, **2512**, **2513**, **2514**, **2515** and **2516**, that is non-driving periods. The received signals **2531**, **2532**, **2533**, **2534**, **2535** and **2535** may be delayed by y**1** compared to the driving signals **2501**, **2502**, **2503**, **2504**, **2505** and **2506**. The position measuring apparatus may measure induced electromotive currents from each of the coils during the second periods **2511**, **2512**, **2513**, **2514**, and **2515**. As described above, when an magnetic field of the electromagnetic wave from the pen is input, an induced electromotive current may be generated based on the magnetic field input from the coil. In the embodiment of FIG. **25**, a size of the third received signal **2533** is larger than those of other signals.

In step **2405**, the position measuring apparatus may determine a position of the pen based on the received signal measured at the coil or the induced electromotive current generated at the coil. For example, the position measuring apparatus may determine a coil of which a received signal or an induced electromotive current is the largest as the position of the pen. Alternatively, the position measuring apparatus may determine the position of the pen based on an interpolation result for the received signal or the induced electromotive current. In the embodiment of FIG. **25**, the position measuring apparatus may determine a coil at which the third received signal **2533** is measured as the position of the pen.

FIG. **26** illustrates a flowchart of a pen position measuring method according to various embodiments of the present disclosure.

In step **2611**, a position measuring apparatus **2601** may apply a driving signal to an electrode during a first period. The position measuring apparatus **2601** may include a plurality of electrodes for measuring a pen position, and may apply the driving signal to a driving electrode among the plurality of electrodes. The position measuring apparatus **2601** may determine a predetermined electrode as the driving electrode among the plurality of electrodes. Alternatively, the position measuring apparatus **2601** may re-determine an electrode corresponding to the determined pen position as the driving electrode for measuring a position of a next pen.

In step **2613**, the driving electrode may transfer a transmission signal to the pen **2602** through a capacitive coupling formed between the driving electrode and the pen **2602**. The driving electrode may form an electric field based on an applied current and the transmission signal of an electric field form may be transferred to the pen **2602**.

In step **2615**, the pen **2602** may generate a resonance based on the transferred transmission signal of the electric field form. The pen **2602** may include a resonance circuit, and may generate the resonance based on the transferred transmission signal. Thus, the pen **2602** may generate an electromagnetic wave.

In step **2617**, the pen **2602** may transfer a received signal of a magnetic field form to the position measuring apparatus **2601** through a inductive coupling formed between each of plurality of coils and the pen. In step **2619**, the position measuring apparatus **2601** may measure the received signals at each coils corresponding to each channel. The position measuring apparatus **2601** may measure the received signals at each electrode corresponding to each channel during a second period where the driving signal is not applied, that is a non-driving period. More specifically, the position measuring apparatus **2601** may measure a received signal at an electrode of a first coil during a first of the non-driving period, and may measure a received signal at a coil of a second channel during a second of the non-driving period. The position measuring apparatus **2601** may measure received signals which are received from all electrodes included therein.

In step **2621**, the position measuring apparatus **2601** may determine the position of the pen based on the received signals which are received from the coil corresponding to each channel. The coils corresponding to each channel may generate induced electromotive currents based on the received signals, and the position measuring apparatus **2601** may determine the position of the pen based on the currents generated from the coils corresponding to each channel. For example, the position measuring apparatus **2601** may determine a coil from which a current having a comparatively large size is generated as the position of the pen. The position measuring apparatus **1501** may determine a y-axis position of the pen **2602** based on induced electromotive currents generated from coils extending in an x-axis direction and may determine an x-axis position of the pen **2602** based on induced electromotive currents generated from coils extending in a y-axis direction.

FIG. **27** illustrates a block diagram of a position measuring apparatus and a pen according to various embodiments of the present disclosure.

As shown in FIG. **27**, a position measuring apparatus **2710** may include a control unit **2711**, a driving unit **2712**, an electrode unit **2713**, a receiving unit **2714** and a coil unit **2715**. In addition, a pen **2720** may include a conductive tip **2721** and a resonance unit **2722**.

The control unit **2711** may control the driving unit **2712** such that the driving unit **2712** provides a driving signal during a first period. The control unit **2711** may control the driving unit **2712** such that the driving unit **2712** is connected to a driving electrode of an electrode unit **2713**. The driving electrode may generate an electric field based on the driving signal transferred from the driving unit **2712** during the first period. The driving electrode of the electrode unit **2713** may form a capacitive coupling with a conductive tip **2721** of the pen **2720**. The driving electrode may transmit a transmission signal of an electric field form to the pen **2720** through a capacitive coupling.

The resonance unit **2722** of the pen **2720** may generate a resonance based on the transmission signal of the electric field form from the driving electrode. An electromagnetic field may be generated by the resonance, and a magnetic field, that is a received signal may be transferred through inductive coupling formed between the resonance unit **2722** and the coil unit **2715**.

The receiving unit **2714** may process the received signals, which are received from each coil of the coil unit **2715** and transmit the processed received signals to the control unit **2711**. The control unit **2711** may control the receiving unit **2714** such that the receiving unit **2714** is connected to the coil unit **2715** during a second period different from the first period. Each of coils of the coil unit **2715** may output currents to the receiving unit **2714** based on the received signals. The receiving unit **2714** may perform, for example, an amplification, a noise elimination, a digital conversion, a conversion into a signal on a frequency area and the like for the received signal or the currents.

The control unit **2711** may measure the position of the pen **2720** based on the received signals or the currents from each coil of the coil unit **2715**. In one embodiment, the control unit **2711** may determine a position of a channel coil of which a received signal or a current is the largest among the received signals or currents from each coil as the position of the pen. In addition, the control unit **2711** may also determine the position of the pen based on a comparative size of the received signals or currents received from each coil. In addition, the control unit **2711** may also determine the position of the pen based on an interpolation result for the received signals or currents from each coil.

FIG. **28**A illustrates a conceptual diagram in a case in which a pen according to various embodiments of the present disclosure touches a panel.

As shown in FIG. **28**A, it is assumed that a pen touches a third electrode **2813** and a third coil **2823**. FIG. **28**B illustrates a transmitted signal and a received signal of a case in which a pen according to various embodiments of the present disclosure touches a panel.

A driving unit may apply driving signals **2831** to **2835** to a driving electrode as shown in (a) of FIG. **28**B. A position measuring apparatus may apply the first driving signal **2831** to the driving electrode during a driving period T**1** and apply the second driving signal **2832** to the driving electrode during the driving period T**1** after a non-driving period T**2**. Each of the driving signals **2831** to **2835** may have an amplitude A. The driving electrode may generate an electric field based on the driving signals **2831** to **2835**.

The pen may generate resonances **2841** to **2845** based on the electric field received from the driving electrode as shown in (b) of FIG. **28**B.

(c) of FIG. **28**B illustrates received signals from each of electrodes **2811** to **2815**. First, during the first period, the received signals **2851** to **2855** may be measured. The third electrode **2813** may have the largest capacitance change due to a touch from the pen to the third electrode **2813**. Therefore, during the first period, as shown (c) of FIG. **28**B, the received signal **2853** from the third electrode **2813** may have the lowest amplitude. A position measuring apparatus may determine the third electrode **2813** of which the received signal **2853** is the least, as an electrode of which a capacitance change is the largest, which is a touched electrode.

During the second period, as shown in (b) of FIG. **28**B, coils **2821** to **2825** may receive received signals **2861** to **2865** from the pen. Since the received signals **2861** to **2865** are an magnetic field by a resonance, the received signals **2861** to **2865** may have alternating current waveforms.

The position measuring apparatus may determine a touch point of the pen based on the received signals **2851** to **2865** during the first period, which is the driving period, from each of the electrodes **2811** to **2815**. In addition, the position measuring apparatus may determine that a touched object is the pen based on the received signals **2851** to **2865** during the second period, which is a non-driving period. When a finger touches, any signal may not be received during the second period. Thus, the position measuring apparatus may determine a type of a touched object as one of the pen and the finger based on a measurement-or-not of the received signal or an existence-or-not of an alternating current waveform during the second period, which is the non-driving period.

FIG. **29** illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure.

In step **2901**, the position measuring apparatus may apply a driving signal to a driving electrode during a first period, that is a driving period. The driving electrode may generate an electric field based on the driving signal during the driving period.

The position measuring apparatus may measure received signals from each coil during a non-driving period, that is a second period. Alternatively, the position measuring apparatus may measure currents from each coil during the non-driving period.

In step **2905**, the position measuring apparatus may determine a type of a touched object based on response attributes of the received signal during the non-driving period. For example, when it is determined that the received signal during the non-driving period includes an alternating current waveform, the position measuring apparatus may determine that the touched object is a pen. In addition, when it is determined that the received signal during the non-driving period does not include an alternating current waveform, the position measuring apparatus may determine that the touched object is a finger. For example, the position measuring apparatus may convert the signal during the non-driving period into a signal on a frequency area and detect whether the signal includes a specific frequency, which is a resonance frequency component to determine whether the signal includes an alternating current waveform. Meanwhile, a person having an ordinary skill in the art may easily understand that a configuration of the position measuring apparatus which determines whether the signal includes an alternating current waveform is not limited.

FIG. **30** illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure. The embodiment of FIG. **30** will be described in more detail with reference to FIGS. **31**A and **31**B. FIGS. **31**A and **31**B illustrate conceptual diagrams of a position measuring apparatus according to various embodiments of the present disclosure. FIG. **31**B illustrates a graph of received signals from electrodes corresponding to each channel according to various embodiments of the present disclosure.

In step **3001**, the position measuring apparatus may apply a driving signal to a driving electrode during a driving period. As shown in FIG. **31**A, the position measuring apparatus may include a display panel **3130** and a substrate **3140**. In addition, one or more coils **3151** to **3155** may be disposed at an upper side of the substrate **3140**.

The position measuring apparatus may determine one among one or more electrodes **3121** to **3126** as the driving electrode and apply the driving signal to the determined electrode.

In step **3003**, the position measuring apparatus may measure received signals from each of the coils **3151** to **3156** corresponding to each channel, in other words, resonance signals, during a non-driving period. For example, the position measuring apparatus may measure the received signals corresponding to each of channels **3151** to **3155***a* as shown in FIG. **31**B. As shown in FIG. **31**B, a resonance signal intensity at the channel **3153***a* corresponding to the third coil **3153** is the strongest. The closer a distance between a pen and an electrode is, the stronger an intensity a magnetic field transmitted and received between the pen and the electrode, which is the resonance signal, may be. In addition, the farther the distance from the pen is, the more the intensity of the resonance signal is reduced. Thus, the position measuring apparatus may determine a position of the pen from a comparative size of such a received signal. In the embodiment of FIG. **31**B, the third coil **3153** of the channel **3153***a* of which the size is the largest may be determined as the position of the pen. Meanwhile, various noise, in addition to the resonance signal generated from the pen, may be simultaneously input to the coils **3151** to **3155**. The input noise may disturb a calculation of an accurate touched position.

FIG. **32** illustrates a flowchart of a control method of a position measuring apparatus according to various embodiments of the present disclosure. FIG. **32** will be described in more detail with reference to FIG. **33**.

The position measuring apparatus according to various embodiments of the present disclosure may extract a signal of a resonance frequency area among received resonance signals. As described above, a resonance signal from a pen may have a resonance frequency. The position measuring apparatus according to various embodiments of the present disclosure may extract a signal of a resonance frequency band, and thus a Signal to Noise Ratio (SNR) may be improved.

In step **3201**, the position measuring apparatus may apply a driving signal to a driving electrode during a driving period. In step **3203**, the position measuring apparatus may measure received signals from each of coils **3311** to **3316** corresponding to each channel during a non-driving period.

In step **3205**, the position measuring apparatus may amplify the received signal measured during the non-driving period. For example, as shown in FIG. **33**, the coils **3311** to **3316** may be connected to an amplifier **3352** through a switch **3351**. The amplifier **3352** may amplify the received resonance signal and transfer the amplified resonance signal to an Analog to Digital Converter (ADC) **3353**.

In step **3207**, the ADC **3353** may convert the received resonance signal of an analog form to a digital signal. In step **3209**, a Digital Signal Processing (DSP) unit **3354** may perform a Fourier transform on the digital signal to convert the digital signal into a signal on a frequency area. In step **3211**, the DSP **3354** may extract a component of a first frequency, that is a resonance frequency, or a band signal including a resonance frequency, among the Fourier-transformed signals. In step **3213**, the position measuring apparatus may determine an input point using the extracted component. Therefore, remaining noise, except for the resonance signal, may be excluded, and thus SNR may be improved.

What is claimed is:

1. A position measuring apparatus, the position measuring apparatus comprising:
- a plurality of electrodes; and
- a processor configured to control to at least:
  - transmit an electric field transmission signal generated from a first electrode among the plurality of electrodes to a pen through a capacitive coupling formed between the first electrode among the plurality of electrodes and a conductive pen tip of the pen during a first period, by applying a driving signal to the first electrode among the plurality of electrodes during the first period,
  - stop transmitting the electric field transmission signal during a second period after the first period, wherein the driving signal is not applied to the first electrode among the plurality of electrodes during the second period,
  - receive, at one or more electrodes among the plurality of electrodes through respective capacitive couplings formed between the one or more electrodes and the conductive pen tip, an electric field reception signal from the pen corresponding to the electric field transmission signal during the second period after the first period,
  - identify a position of the pen based on a comparative size of a current output from the one or more electrodes that receive the electric field reception signal during the first period, and
  - identify the position of the pen based on a strength of the electric field reception signal which is received at the one or more electrodes during the second period,
- wherein the pen is configured to generate an electromagnetic reception signal comprising the electric field reception signal and a magnetic field reception signal by producing resonance based on the electric field transmission signal, and
- wherein the first period is not overlapping the second period.

2. The position measuring apparatus of claim **1**, further comprising:
- an amplifier configured to amplify the electric field reception signal; and
- an analog to digital converter configured to convert the amplified reception signal,
- wherein the processor is further configured to:
  - convert the converted amplified reception signal to a reception signal on a frequency area,
  - extract a resonance frequency component from the reception signal on the frequency area, and

determine the position of the pen based on the resonance frequency component.

3. The position measuring apparatus of claim 1, wherein the processor is further configured to:

determine an electrode corresponding to the position of the pen, and

determine the electrode corresponding to the position of the pen as the first electrode among the plurality of electrodes for generating the electric field transmission signal for a next position measurement.

4. The position measuring apparatus of claim 1, wherein the first electrode among the plurality of electrodes does not apply the driving signal during the second period.

5. The position measuring apparatus of claim 1, wherein the processor is further configured to control to detect a touch pressure of the pen based on a frequency of the electric field reception signal.

6. The position measuring apparatus of claim 1, wherein the processor is further configured to determine a switch on and a switch off condition of the pen based on a frequency of the electric field reception signal.

7. The position measuring apparatus of claim 1,

wherein the first electrode among the plurality of electrodes is included in the one or more electrodes among the plurality of electrodes,

wherein the processor is further configured to control so that the first electrode among the plurality of electrodes generates the electric field transmission signal in the first period, and to stop the transmission of the electric field transmission signal in the second period, and

wherein the processor is further configured to control so that the first electrode among the plurality of electrodes receives the electric field reception signal during the second period.

8. The position measuring apparatus of claim 1, wherein the one or more electrodes through which the electric field reception signal is received comprises the first electrode among the plurality of electrodes from which the electric field transmission signal is generated.

9. A position measuring apparatus, the position measuring apparatus comprising:

a plurality of electrodes;

a driving circuit configured to apply a driving signal to a first electrode among the plurality of electrodes during a first period, wherein the first electrode among the plurality of electrodes transmits an electric field transmission signal to a pen through a capacitive coupling formed between the first electrode among the plurality of electrodes and a conductive pen tip of the pen; and

a processor configured to at least:

control to stop applying the driving signal such that the transmission of the electric field transmission signal from the plurality of electrodes is stopped, during a second period after the first period,

determine a position of the pen based on a comparative size of a current output from the one or more electrodes that receive the electric field reception signal during the first period, and

determine the position of the pen based on a strength of a current, which corresponds to a strength of an electric field reception signal, generated from one or more electrodes among the plurality of electrodes that receive the electric field reception signal from the pen through respective capacitive couplings formed between the one or more electrodes and the conductive pen tip of the pen during the second period,

wherein the pen generates an electromagnetic reception signal comprising the electric field reception signal and a magnetic field reception signal by producing resonance based on the electric field transmission signal, and

wherein the first period is not overlapping the second period.

10. The position measuring apparatus of claim 9,

wherein the first electrode among the plurality of electrodes is included in the one or more electrodes among the plurality of electrodes,

wherein the processor is further configured to control to apply the driving signal to the first electrode among the plurality of electrodes during a first time period and to stop applying the driving signal to the first electrode among the plurality of electrodes during a second time period, and

wherein the processor is further configured to control so that the first electrode among the plurality of electrodes receives the electric field reception signal during the second time period.

11. The position measuring apparatus of claim 9, wherein the one or more electrodes through which the electric field reception signal is received comprises the first electrode among the plurality of electrodes from which the electric field transmission signal is generated.

12. A method for determining a position of a pen at a position measuring apparatus, the method comprising:

transmitting, from the position measuring apparatus, an electric field transmission signal generated from a first electrode among a plurality of electrodes of the position measuring apparatus to the pen through a capacitive coupling formed between the first electrode among the plurality of electrodes and a conductive pen tip of the pen during a first period, by applying a driving signal to the first electrode among the plurality of electrodes during the first period;

stopping transmitting the electric field transmission signal during a second period after the first period, wherein the driving signal is not applied to the first electrode among the plurality of electrodes during the second period;

receiving, from the pen, an electric field reception signal corresponding to the electric field transmission signal at one or more electrodes among the plurality of electrodes of the position measuring apparatus through respective capacitive couplings formed between the one or more electrodes and the conductive pen tip during the second period;

identifying a position of the pen based on a comparative size of a current output from the one or more electrodes that receive the electric field reception signal during the first period; and

identifying the position of the pen based on a strength of the electric field reception signal which is received at the one or more electrodes during the second period,

wherein the pen generates an electromagnetic reception signal comprising the electric field reception signal and a magnetic field reception signal by producing resonance based on the electric field transmission signal, and

wherein the first period is not overlapping the second period.

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